
THE

ENCYCLOPÆDIA BRITANNICA,

OR

DICTIONARY

OF

ARTS, SCIENCES, AND GENERAL LITERATURE.

EIGHTH EDITION.

WITH EXTENSIVE IMPROVEMENTS AND ADDITIONS;
AND NUMEROUS ENGRAVINGS.

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ENCYCLOPÆDIA BRITANNICA.

ENTOMOLOGY.

So numerous and diversified are the subjects of entomological science, that a detailed exposition of the CLASS INSECTA is scarcely compatible with the limits usually assigned to a treatise in a compendious work, such as that with which we are now engaged. It may indeed be made to present a general, and at the same time systematic, view of the science, sufficiently ample to convey an accurate idea both of the individual character and the general relationship of groups, but it cannot fill these up in such a way as to exhibit the minuter features of their component parts, or their delicate differences or agreements in structural form, instincts, and modes of life. The chief use of such a treatise must ever be to serve as a guide or indication to the student regarding the sources from which he is to draw a more extended and complete acquaintance with a subject so wondrous in itself, that the more it is investigated and understood, the deeper and more delightful will become the interest by which it is naturally invested.

The division of labour in natural history now implies not only the separation, as distinct departments of study, of the primary classes of the animal kingdom from each other, but also the subdivision of those classes into many minor groups, each of which by itself alone is more than sufficient to occupy, if not exhaust, the entire attention of the most devoted naturalist. It is thus that those who have sought and found distinction in the scientific field have usually, in recent years, confined their more sedulous and painstaking researches to some special department; and in entomology more particularly, from its vast extent and extraordinary diversity, great advantage has arisen from its votaries selecting certain ordinal or other groups as the subjects of exclusive study, instead of endeavouring to diffuse themselves more widely and feebly over the entire expanse. But this mode of treatment, and the amplification which it admits of and requires, while beneficial to the science, have caused its branches to shoot forth and flourish so luxuriantly, that what was once a lowly shrub is now a lofty tree, the flowers or fruit of which can scarcely be gathered by any single unassisted son of Adam. Hence the difficulty of the Encyclopædist, who has boldly to present a picture of the whole, while he knows in his heart that it consists of such an infinity of various parts as no man can number. We found the subject sufficiently trying several years ago, when the treatise here presented was composed. We find it still more burdensome and laborious now, when the divisional system just alluded to has been acted on so fully, and with such success. A recent general system of entomology can scarcely be said to exist, so independently have the exponents of particular portions extended their researches, each widening his scope in consequence of finding himself disembarrassed from all consideration of the neighbouring fields. To give therefore a satisfying exposition of the science of insects, each great ordinal group would now require to have assigned to it a treatise for itself. But this, as we have said, would be incompatible with the compendious character of an Encyclopædia, and so a general systematic view must be taken of the entire subject under the single head of ENTOMOLOGY.

After a careful consideration of the changes which the science has recently undergone, and bearing in mind the impossibility of including an adequate account of all that has been added to the different orders during later years, we have come to the conclusion to adhere to the system of Latreille, the great French entomologist, as on the whole the most satisfactory, and certainly the most generally received. But that the student who desires to extend his more special researches into particular orders may be advised regarding the best authors which treat of these, or other great subdivisions, we shall prefix to our general treatise a bibliographical introduction, which we trust may prove of service. To increase the interest and instructiveness of our list, we shall add a few biographical notices, and arrange our subjects somewhat chronologically, under the names of their respective authors.

An alphabetical arrangement, like an artificial system in natural history, might possibly have been advisable, as more convenient, and as admitting of direct reference to individual authors the titles of whose works the student seeks to know. But we think that a near approach to a chronological arrangement has this great advantage, that it shows,

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as it were, the increasing strength and breadth of the great entomological stream, as it flows downwards from an early epoch towards our own days. On these grounds, therefore, we shall abstain from adding unnecessarily to the length of this treatise by an alphabetical list of authors, as the omission will be found to be in a great measure compensated for by the copious nature of the *chronological catalogue.*

The number even of known insects far exceeds that of the members of any other class of the animal kingdom. From the general smallness of the majority, and the extreme minuteness of many, it may be fairly inferred that a vast amount are as yet unknown, especially in foreign countries where, for purposes of traffic, large and showy species are usually in most request. We have somewhere seen it stated that beetles were of two kinds—the black and the brown. Naturalists are now acquainted with not less than 35,000 insects of that order. Above 12,000 different sorts of butterflies and moths have been collected; and in Britain alone, though with somewhat of a cold and cloudy clime, we have about 2000 species of the Lepidopterous order. Several of the other great ordinal divisions contain an equal number of component members, so that the entire amount of insects now described by naturalists may be safely computed as above 72,000. If we were to devote a page a-piece to these, (and we have no desire to doubt that each deserves it), then we should require to occupy about four times the contents of the present *Encyclopædia,* to the entire exclusion of all other subjects, which would be inconsistent with the object of this great work.

It is more than 150 years since John Ray tried to astonish the English public by boldly stating that so numerous were both beetles and butterflies in this country, that he believed the species of each kind might amount to more than 150. "The fly kind," he continues, "will be found in multitude of species to equal, if not exceed, both the forementioned kinds. The creeping insects that never come to be winged, though for number they may fall short of the flying or winged, yet are they also very numerous; as, by running over the several kinds, I could easily demonstrate. Supposing, then, there be a thousand several sorts of insects in this island, and the sea near it, if the same proportion holds between the insects native of England and those of the rest of the world, as doth between plants domestic and exotic (that is, as I guess, near decuple), the species of insects in the whole earth (land and water) will amount to 10,000; and I do believe they rather exceed than fall short of this sum." The subject, however, seems to have grown fast upon him, for at an after period he estimated the total number of British insects as possibly 2000, and those of this terraqueous globe at 20,000. Now, in Mr Stephens' *Catalogue of British Insects,* published twenty-six years ago, we have an enumeration of 10,012 species, and numerous additions have been made during the intervening years. So far back as 1821 Mr Macleay calculated the number of the Annulosa (Insects and Crustacea) preserved in the various collections of Europe, as amounting to 100,000. It is not surprising then that entomological science should now be so frequently subdivided, and the practice followed of each order, or other great natural group, being selected by different individuals as the exclusive object of attention.

NOTICES REGARDING THE PRINCIPAL AUTHORS IN ENTOMOLOGY AND THEIR WORKS.

We need say nothing of the remote history of insects, as so little has been recorded of them by ancient writers. Aristotle, the earliest, and still one of the most remarkable of naturalists, appears to have separated the Crustacea as a particular group, under the title of *Malacostraca,* from the *Entoma* or other insects. These latter he subdivided into *Entoma ptilota* and *Entoma aptera*—the winged and the wingless tribes; and these again he further separated into various minor groups, for the greater part extremely natural, even when viewed by the lights of modern knowledge. Aristotle's attainments in natural history were truly extraordinary, and many of the finest generalizations from ascertained structure are to be found in his zoological writings. His disquisitions on a group, the Cuttle-fish, not belonging to our present department, may be cited as deserving of the highest praise even at the present day, and it is indeed only during recent years that modern naturalists have themselves attained a sufficient knowledge of certain truths of nature, from actual observation, to be qualified to judge of and appreciate what he knew.

The works of Pliny and Ælian need find no place in the library of the entomologist. So passing over a period of more than 1800 years from the days of Aristotle, we come to—

CONRAD GESNER, a poor but industrious Swiss, who was born in 1516, and is by many regarded as the restorer of natural history. He became a physician at Zurich, and gathered together all that was known relating to the history of animals, thus filling five large folio volumes with that of the Vertebrata alone. His posthumous papers on insects fell eventually into the hands of Thomas Mouffet, and were published by him under the title of *Insectorum sive minimorum Animalium Theatrum.* Folio, fig.; London, 1634. Gesner was one of the first, after the revival of learning, to form collections of objects in natural history, his predecessors having chiefly confined themselves to writing commentaries on the ancients, not seldom rendering "confusion worse confounded," and darkening knowledge by a multiplicity of vain words. He was a man of singular learning,—*monstrum eruditionis,* as he is termed by Boerhaave, and has been regarded by many as the greatest naturalist from the days of ARISTOTLE up to a comparatively recent time.

ULYSSES ALDROVANDUS, also a learned and laborious compiler, was contemporary with Gesner. He was a nobleman of Bologna, professor in the university there, was born in 1525, and died blind in 1605. He wrote fourteen folio volumes on "Natural History," which Baron Cuvier has termed "an indigested and wearisome compilation." It is certainly not very methodical, but many parts of it may be read with amusement, if not with instruction. It was published chiefly by his successors. There are two editions in folio of his treatise on insects, termed *De Animalibus Insectis libri septem,* Bonon., 1602; Frankf., 1618–23. He divides them into terrestrial and aquatic, and the orders are formed from the presence, the number, and the disposition, of the legs and wings. His groups are often arbitrary and unmeaning. He may be likened to Pliny, as one who made a collection of almost all that was known on the subjects of which he treated prior to his own time. The desirable power of discriminating truth from fiction was not, however, among his characteristics.

D. J. HŒFNAGEL was a painter, and a man of good observation. He left behind him very exact representations of a number of insects, which were engraved at Antwerp in 1630 and 1646, under the title of *Diversæ insectorum volatilium icones ad vivum depictæ.* The plates constitute its chief excellency, the letter-press being of less value. —*Archetypa Insectorum.* 4 vols. fol., Frankf., 1692.

THOMAS MOUFFET, an English naturalist and physician, died about 1600. His entomological work, which is remarkable as the first special one on insects, is entitled *Insectorum sive minimorum Animalium Theatrum.* It was published by Theodore Mayerne, a Frenchman, and physician to James the First, in one volume folio, with 500 woodcuts, London, 1634. It is greatly in the style of Gesner, to whose manuscripts he had access, and from which he borrowed largely.

—— AALBORG. *De Cultura Apum.* Copenhagen, 1639. —*Tractatus de Apibus.* Hafniæ, 1642.

It was about this period that the celebrated Harvey

ventured to controvert the ancient opinion regarding the equivocal or spontaneous generation of insects; and although his philosophical aphorism of *omnia ex ovo* was some time of receiving a general approval, yet his own experiments, and those more especially of Redi and Malpighi, soon afforded a firm and incontrovertible basis for the maintenance of that opinion.

Joseph Warden. This old writer devoted his attention to industrial insects, and has published, *Apiarium, or a Discourse of Bees*, &c., 8vo, London, 1676.—*A further Discovery of Bees, treating of the Nature, Government, Generation, and Preservation of the Bees*, by Mos. Rasden. 8vo, fig., London, 1680.—*The true Amazons, or the Monarchy of Bees.* 8vo, London, 1713.

Francesco Redi of Arezzo, a physician, and a man of excellent literary attainments, was born in 1626, and died in 1698. His observations were first published in Italian, at Florence, in 1668, and afterwards at Amsterdam in 1671, and following years, under the title of *Experimenta circa Generationem Insectorum.* 3 vols. 12mo, with plates.

John Goedart published a work in Dutch, which was afterwards translated into Latin: *Metamorphosis et Historia Naturalis Insectorum.* 3 vols. in 8vo, 1662–7, with plates. It contains some original facts, and the figures of the species are still recognizable. This author was a Dutch painter, and among the earliest to attend to the transformations of insects. An English edition of his work was published by Dr Martin Lyster in 4to, York, 1682.

Marcellus Malpighi was the author of some excellent treatises on the anatomy of insects. His *Dissertatio de Bombyce* explains the structure of the silk-worm. It forms a small volume of 100 pages 4to, with twelve plates, published in London in 1669, and is reprinted in the second volume of his *Opera Omnia*, 1686.

John Swammerdam, the most remarkable writer on the anatomy of insects, was a Dutch physician, born at Amsterdam in 1637. He died in 1680. He published a general history of insects in Dutch, about the year 1669, which was translated into both French and Latin. We may here observe, that the methodical arrangement of articulated animals, from the time of Aristotle and other ancient writers, down to so late a period as the days of the great Dutch observer, was extremely simple. The principal divisions were formed in relation to the medium which they inhabit, the presence, the consistence, and the number, of the feet and wings. But the work of Swammerdam, republished at Leyden in 1737–8, under the title of *Biblia Naturæ, sive Historia Insectorum in classes certas redacta*, &c., 2 vols., folio, with plates, created an epoch in the science. The great merit of this remarkable writer consists in the light which he threw upon the mysteries of metamorphoses; and a marked character of his classification results from his having partly based it upon the nature of those transformations.

Swammerdam disposes of his articulated animals under four principal orders:—The first comprehends all insects (so called) which leave the egg in a completed state, and provided with all their members; they increase in size by degrees, and their metamorphosis consist, not in any striking transformation, but rather in a simple casting of the skin. He here places spiders, lice (of the structure of which he gives a very circumstantial account), ticks, wood-lice or *slaters*, entomostraca, scorpions, earth-worms, leeches, and others. His second order contains such as leave the egg with six feet, and arrive at the perfect state through the medium of nymphæ, of active habits, and furnished with the rudiments of wings. They become perfect by the casting of their skin, and the great and rapid expansion of their wings. Here we have the *Libellulæ* or dragon-flies, the *Nepæ* or water scorpions, the *Ephemeræ*, and other tribes, which, in the modern systems, are classed under the different orders of Neuroptera, Orthoptera, and Hemiptera. Swammerdam's third order is composed of such insects as exhibit distinct members in the nympha state, but are incapable in that condition of locomotion, such as the coleopterous and hymenopterous tribes; he also here includes such as undergo a more complete metamorphosis, for example, the lepidopterous order, of the singular and previously unexplained transformations of which he gives an admirable account, by narrating his own observations on the nettle and cabbage butterflies. His fourth order comprehends those species which change into an egg-like or *obtected* chrysalis, and corresponds to the order Diptera of our modern systems. The work in general is of the greatest value in the study of the organization of insects, and abounds in curious facts illustrating the natural history and anatomy of animals. "It was a great point gained in the science," says Mr Kirby, "to introduce the consideration of the metamorphosis, and to employ it in the extrication of the natural system; for though when taken by itself it will, as in the table just given, lead to an artificial arrangement, it furnishes a very useful clue when the consideration of insects in their perfect state is added."

Martin Lyster, an English naturalist, and physician to Queen Anne, died in 1711. He published in 1685 a methodical edition of Goedart, *cum Scarabæorum Anglicanorum quibusdam tabulis mutis.* He was a contemporary and coadjutor of Ray, and by his various writings threw great light on many points of Entomology. His character as an entomologist, or rather as an arachnologist, was, however, chiefly established by his excellent treatise *De Araneis*, in which he describes the spider tribes with great accuracy.

Madame Sibilla Merian, a Dutch lady of German family, was born in 1647, and died in 1717. She composed several entomological works, some of which were published posthumously. They are remarkable for the beauty of the plates; and being rare from the small number of examples thrown off, are rather sought after by the bibliographical naturalist. Their titles are, *Metamorphosis Insectorum Surinamensis.* Amstel. 1705.—*Erucarum Ortus alimentum et paradoxa metamorphosis.* Amstel. 1718, with fifty plates. She also wrote a history of European insects, translated into French by M. Mairet, one vol. folio, 1730. There seem to be various editions of her works, in all of which, however, the plates are the same.

Antony Leuwenhoeck, a Dutch naturalist, famous for his microscopical observations, and one of the improvers of the microscope itself, was born at Delft in 1632, and died in 1723. He published a work in five small 4to volumes, entitled *Arcana Naturæ, ope Microscopiorum detecta.* Delphis, 1695, 1721. His *Select Works* were published in English by Samuel Hoole, two vols. 4to, 1798. There is no arrangement in his works, the objects being described as they happened to occur; and though the style is rather tedious from the laborious minuteness of his investigations, he has thrown great light upon the history of gall-insects, ants, bees, gnats, and the larvæ of the genus *Tenthredo.*

Antonio Vallisnieri, an Italian naturalist, of a noble and ancient family, was born in 1661, and died in 1730. He was a man of learning, and an admirable observer and narrator. His first work was published at Venice in 1700, under the name of *Dialoghi sopra la curiosa origine, sviluppi e costumi di varii Insetti.* His collected works form three small folio volumes, with many plates exceedingly well engraved, and contain a mass of interesting information, original at that period, and still held in estimation.

John Ray, an English divine, was born in 1628, and died in 1705. He is admitted by Baron Cuvier to have been the first true methodizer of the animal kingdom, and the principal guide of Linnæus in that department of natural science. He published his *Methodus Insectorum, seu Insecta in methodum aliqualem digesta* in 1705; but his larger work, the *Historia Insectorum* (which, as appears

from his *Philosophical Letters*, was a kind of joint production of his own and Willughby's) was published by Lister after his death.

About this same period Sir Hans Sloane flourished in England. His collections formed the original nucleus of the British Museum, and he greatly contributed, by his zeal and disinterestedness, to the general extension of knowledge in natural history.

ELEAZER ALBIN, an English painter, published a work under the title of *Insectorum Angliæ Naturalis Historia*, with notes and observations by W. Derham, London, 1731.

RENE-ANTOINE FERCHAULT DE REAUMUR, born in 1683, died in 1757, was the author of one of the most important works which has ever appeared on any branch of natural history. It bears the title of *Mémoires pour servir à l'Histoire des Insectes*, and is composed of 6 vols. in 4to, which made their appearance from 1734 to 1742. His skill and patience in the observance of the manners of insects have never been excelled, and the only objection to his incomparable work is its want of systematic arrangement. It contains numerous plates.

ALBERT SEBA, an apothecary of Amsterdam, born in 1665, died in 1736, published many figures of insects in his *Thesaurus*, a work in 4 folio volumes, Amsterdam, 1734, 1765. The plates are good, though badly coloured. The text is of no value. The author was a zealous and successful collector of objects in natural history.

CAROLUS LINNÆUS, "the immortal Swede," professor at Upsal, and the great founder or reformer of the modern system and nomenclature of natural history, was born in 1707, and died in 1778. One of his many great merits consists in his having given *definitions* of those generic groups which his predecessors had merely distinguished by the imposition of vague *names*. Another noted excellence was the invention of *trivial* names. The older naturalists, as Mr Kirby has remarked, used to treasure in their memories a short description of each species, by which, when they desired to mention it, they made it known. For example, in speaking of our common Lady-bird, they would call it "the Coccinella with red coleoptera having seven black spots." This long enunciation was first called the *titulus* or *title*, and afterwards the *nomen specificum*, or specific name. But as the number of species increased, it became no easy matter to remember even a few thousands of these definitions; and, with a view to remedy that inconvenience, Linnæus invented what is called the *nomen triviale*, which expresses any species by a single term added to its generic appellation, such as *Coccinella septem-punctata*, for the species just alluded to. In his definitions he confined himself to twelve words, a whimsical restriction, which, while it avoids prolixity, would, in our now immensely swollen faunas, confound the species, by rendering the same expressions applicable to several different kinds. Although his system is professedly artificial, his tact for the discovery of natural groups in general seems to have been almost intuitive.

The entomological system of Linnæus is founded on the presence or absence of the wings, their number, consistence, surface, respective position in repose, and the presence or absence of a sting. This classification, so far as the orders are concerned, has served as the basis of all that have been since promulgated; and it underwent various modifications and improvements in the course of the numerous editions of the *Systema Naturæ*. Of these, twelve were published during the author's lifetime. The first edition (1735) consisted of only 14 folio pages; the twelfth is in 3 vols. 8vo, 1766–68; the thirteenth was greatly enlarged by Gmelin, 7 vols. 8vo, Leipz. 1788–93. There have been numerous reprints in all countries. The English translation by Turton is in 7 vols. 8vo, Lond. 1806. The *Fundamenta Entomologiæ*, by W. Curtis (1772), and the *Institutions of Entomology*, by Yates (1773), are transcripts from the *Systema Naturæ*.

The following table presents a view of the Entomological *orders* of the great Swedish naturalist.

Wings.	4,	Superior	crustaceous, with a straight suture,		COLEOPTERA,	1st order.
			semicrustaceous, incumbent,		HEMIPTERA,	2d ...
		All	imbricated with scales,		LEPIDOPTERA,	3d ...
			membranous. Anus	unarmed	NEUROPTERA,	4th ...
				aculeate	HYMENOPTERA,	5th ...
	2,	Poisers in place of the posterior pair,			DIPTERA,	6th ...
	0,	Or without either wings or elytra,			APTERA,	7th ...

JOHN LEONARD FRISCH, rector of the gymnasium of Berlin, was born in 1666, and died in 1743. Besides his well-known work on birds, he wrote on German entomology, *Beschreibung von Insecten in Teutschland.* 1 vol. 4to, with plates, Berlin, 1720–38.

J. DUTFIELD. *New and Complete Natural History of English Moths and Butterflies, considered through all their Progress, States, and Changes.* Lond. 1748–49.

B. J. v. BUCKWALD. *Insectologiæ Danicæ Specimen.* 4to, Hafn. 1760.

ROESEL DE ROSENHOF, a painter of Nuremberg, was born in 1705, and died in 1795. He was an ingenious and accurate observer, and represented subjects of natural history with fidelity. He published an entomological work called *Insecten Belustigungen*, in 4 vols. 4to, with excellent coloured plates, Nuremb. 1746, *et seq.* Besides the beauty of the illustrations, the author enters into many interesting details relating to the structure, the manners, and the metamorphoses of insects. A supplement (forming the 5th vol.) to Roesel's work was published by Kleeman, his son-in-law:—*Beytræge zur Natur Oder Insecten geschichte.* Nuremb. 1761.

JOHN HILL. *A Decade of Curious Insects; shewn in their Natural Size, and as they appear Enlarged before the Lucernal Microscope, in which the Solar Apparatus is artificially illuminated.* 4to, col. fig., Lond., 1773.

CHARLES BONNET, a noted philosopher and naturalist of Geneva, was born in 1720, died 1793. At twenty years of age he published an excellent Memoir on the Aphides, or *pucerons*, which is combined with many others in his *Traité d'Insectologie.* His works were published in 9 vols. 4to, in 1779. He was an excellent observer.

JACOB ADMIRAL published a Dutch folio on butterflies: *Insectes gravés en manière Noir avec l'Explication des Planches en Hollandais.* Folio, fig. 1740. It contains twenty-five coloured plates, deservedly esteemed by naturalists.

CHARLES DE GEER, a Swedish baron, marshal of the court, and member of the Academy of Stockholm, was born in 1720, and died in 1778. His work is written in French, though published at Stockholm, in 7 vols. 4to, 1752–1778, and bears the same title as that of Réaumur (*Mem. pour servir à l'Histoire des Insectes*), to which it may be regarded as a sequel. The first two volumes are rare, and a general abridgment of the whole was given by Retzius in a Latin work entitled *Genera et Species Insectorum*, 1 vol. 4to, Lipsiæ, 1783. There is also a German translation, enlarged by Goez.

These celebrated *Mémoires* are very similar in their scope to those of Réaumur; but they are conducted, especially the last five volumes, in a much more methodical manner. The first volume contains sixteen memoirs on caterpillars, and a seventeenth in which he describes their enemies the Ichneumonidæ, and other foes. The second volume is divided into two parts, and is devoted to the history of those insects which possess four naked wings; it is

preceded by several general discourses on the habitations, food, generation, and transformations of insects. The same volume contains the insects with farinaceous wings; those with membranaceous wings, the mouth without teeth or trunk, which the author distinguishes from such as, likewise possessing membranaceous wings, are provided with teeth, and are inter-distinguished by the absence or possession of a sting. In the third volume we find the history and description of those four-winged insects of which the wings are sometimes entirely membranaceous, sometimes demi-coriaceous, and provided with a beak or sucker; likewise of those which correspond to the orthopterous order. The fourth and fifth volumes contain the history of the coleopterous tribes, classed according to the number of the articulations of the tarsi. We may here note, that these volumes appeared in 1774–5, that is, ten years after Geoffroy's publication, to be afterwards mentioned, to which we owe the first establishment of the characters drawn from the articulations. The sixth volume is devoted to the dipterous or two-winged insects, and to the Coccus tribe or kermes. The seventh volume contains the history of the apterous insects. The system of De Geer, which is contained in a posthumous volume published in 1778, may be regarded as intermediate between that of Linnæus and Fabricius, because, though based like the former upon the organs of flight, and in its ternary groups equivalent to the Linnæan orders, it likewise takes into consideration the parts of the mouth, or organs of manducation, and may thus, as Mr Kirby has remarked, have been the means of suggesting to the latter the first idea of assuming the last-mentioned instruments as the basis of a new method. "But though partaking of both, it is nearer to nature than either; and had its illustrious author laid less stress upon the number and substance of the organs of flight, it would probably have been as near perfection in this respect as most that that have succeeded it. But following too strictly these characters, he has been led to place in different classes, or rather orders, insects that ought not to have been so separated, as in the case of the two sections of the *Hemiptera* and the *Coccidæ*. In other respects, the whole of De Geer's *Mémoirs* are a storehouse of valuable observations, in which he has furnished many a clue for threading the labyrinth of nature, and given most complete and interesting histories of the whole economy and habits of many tribes and genera, as of the *Trichoptera*, *Aphides*, *Ephemerina*, &c." The importance attached, both actually and historically, to this celebrated system, induces us to present its principal features to the reader in the following tabular view.

	GENERAL CLASSES.	ORDERS.	CLASSES.
INSECTS.	I. Having wings.	I. Four wings without wing-cases.	I. *Wings* covered with scales. *Tongue* spiral. LEPIDOPTERA.
			II. *Wings* membranous, naked. *Mouth* without teeth or tongue. TRICHOPTERA, EPHEMERINA.
			III. *Wings* membranous, equal, reticulated. *Mouth* with teeth. Rest of NEUROPTERA.
			IV. *Wings* membranous, unequal, nervures mostly longitudinal. *Mouth* with teeth. A *sting* or *borer* in the female. HYMENOPTERA.
			V. *Wings* membranous. Tongue bent beneath the breast. HOMOPTERA of Leach.
		II. Two wings covered by two wing-cases.	VI. *Elytra* half coriaceous and half membranous, crossed. A pair of membranous *wings*. Tongue bent beneath the breast. HEMIPTERA of Leach.
			VII. *Elytra* coriaceous or semi-crustaceous, aliform. A pair of membranous *wings*. *Mouth* with teeth. ORTHOPTERA.
			VIII. *Elytra* hard and crustaceous. A pair of membranous *wings*. *Mouth* with teeth. COLEOPTERA.
		III. Two wings uncovered.	IX. A pair of membranous *wings*. A pair of *poisers*. *Mouth* with a tongue, without teeth. DIPTERA.
			X. A pair of membranous *wings*. No *poisers*, *tongue*, or *teeth* in the male. No *wings*, but a *tongue* in the breast of the female. COCCUS, L.
	II. Without wings.	IV. Undergoing a metamorphosis.	XI. No *wings*. Six *legs*. *Mouth* with a *tongue*. APHANIPTERA.
		V. Undergoing no metamorphosis.	XII. No *wings*. Six *legs*. *Head* and *trunk* distinct. HEXAPOD APTERA, TERMES, PSOCUS.
			XIII. No *wings*. Eight or ten *legs*. *Head* united to the *trunk*. OCTOPOD APTERA, ARACHNIDA, CRUSTACEA.
			XIV. No *wings*. Fourteen *legs* or more. *Head* distinct from the trunk. POLYPOD APTERA, CRUSTACEA.

We shall merely add, that the two principal divisions of winged and apterous insects, divided into the fourteen orders above enumerated, comprised 1446 species, referrible to 100 genera. How meagre such an amount appears when compared with the extended lists of modern days!

CHARLES CLERCK, a Swedish painter, and a pupil of Linnæus, published a 4to volume in the Swedish and Latin languages, entitled *Aranei Suecici descriptionibus et figuris illustrati*, 1757, in which the habits of spiders are well described. He was also the author of *Icones Insectorum rariorum*, 1759–64, useful as an index to the Lepidoptera described by Linnæus from the collection of Queen Frederica Ulrica.

JOHN HENRY SULZER composed a work in German on the characters of insects, *Die Kennziechen der Insecten*, with figures, 1 vol. 4to, Zurich, 1761.

PETER LYONNET, interpreting secretary to the united provinces, was born in 1707, and died in 1789. He was the author of the celebrated *Traité Anatomique de la Chenille de Saule*, 1 vol. 4to, 1762. He himself engraved the plates to the work, and both the letter-press and illustrations are masterpieces in their way. They were declared by the excellent Bonnet to afford a *demonstration* of the existence of God. Lyonnet was a man of fine accomplishments, spoke nine languages, and was one of the greatest insect anatomists that the world ever saw. The work above named is an extraordinary example of skill and patience. There are 4061 muscles enumerated as existing in the head, body, and around the intestines of the caterpillar of the *Cossus ligniperda*.—a number greater by about 3532 than is known to exist in the whole human body. Dr de Haan of Leyden has published a posthumous work of the same great observer, entitled *Recherches sur l'Anatomie et les Metamorphoses des differentes espèces d'Insectes*. 4to, 1st and 2d parts, Paris, 1832.

CHR. SEPP is the author of a work in Dutch, on the insects of the Low Countries, entitled *Beschouwing der Wonderen Gods in de Minstgeachte Schepzelen of Nederlandsche Insecten*, 3 vols. 4to, Amsterdam, 1762, &c. This work came out originally in numbers, and perfect sets are now extremely rare. The plates, in Mr Swainson's opinion, have never been equalled, far less excelled, by the most successful efforts of modern art.

J. A. SCOPOLI, professor of botany and chemistry at

Pavia, born in 1723, died in 1788. He was the author, among other works, of the *Entomologia Carniolica*, 1 vol. 8vo, 1763. The general arrangement of Scopoli in his *Introductio ad Historiam Naturalem* (Pragæ, 1777) is bad; but his genera are frequently well grouped, and their characters judiciously constructed. Not a few of them may be found in more recent systems under other names. He appears to have published an incompleted sequel of plates to the work first named. It is but little known.

Geoffroy, a celebrated French physician, was the author of the *Histoire abrégée des Insectes des Environs de Paris*, 2 vols. with plates, 1764. It is a methodical work, and deservedly esteemed by entomologists. His divisions, deduced from the characters of the wings, accord closely with those of Linnæus; but the Hymenoptera and Neuroptera are included in the same order, and the Orthoptera form only a section of the coleopterous tribes. He was the first to signalize and make use of the number of articulations of the tarsi, as we have already stated in our notice of De Geer. The *Entomologia Parisiensis*, 2 vols. 8vo, 1785, a youthful work of Fourcroy, the great French chemist, appears to be a mere abridgment of that above named.

John Christian Schæffer, a clergyman of Ratisbonne, was born in 1718, and died in 1799. He published *Abhandlungen von Insecten*, 4to, Regenst. 1769–79; and likewise a large collection of plates of the insects of his own neighbourhood,—*Icones Insectorum circa Ratisbonam Indigenorum*, 3 vols. 4to, Regenst. 1766–79. The designations are those of Linnæus. The work is well executed, and presents a careful development of the most important characters. He at the same time published a separate volume under the title *Elementa Entomologica*, likewise with coloured plates, 35 in number. To these he added a supplement in 1777. Although the names of his classes are different, yet the classes themselves coincide with those of Geoffroy. There is a later edition of the *Icones*, with Systematic Index by Panzer: Erlang. 1804.

O. F. Muller, among numerous noted works in other departments of natural history, published a *Fauna Insectorum Fredrichsdalina*. Hafniæ, 1764.

Martin Thomas Brunnich, a Danish naturalist, and professor at Copenhagen, was the author of *Prodromus Insectologiæ Ziællandicæ*, 8vo, Hafniæ, 1761, and of *Entomologia, sistens insectorum tabulas systematicas*, Hafniæ, 1764. The latter work contains plates in outline, representing the characteristic part of insects. In a short introduction he also presents a view of the structure of insects, and then furnishes us with a classification, not only of the insects themselves, but of entomologists, or *Insectistæ*, as he is pleased to call them. The reader may perhaps like to see his arrangement of these people. It is as follows:—

I. Entomologists. A. Collectors: 1°, Ancients or Fathers (Patres), such as Aristotle, Pliny, Dioscorides; 2°, Commentators, the same; 3°, Ichniographers or figurists, such as Goedart, Hoefnagel, Merian, Vallisnieri, Albin, Frisch; 4°, Metamorphosists, such as Swammerdam; 5°, Describers, such as Ray and Linnæus; 6°, Monographists, such as Lister, Schœffer, and Clerk; 7°, Curiosi, such as Catesby, Ström, Pontoppidan; 8°, Museographists, such as Linnæus and Poda; 9°, Topographers, such as Albin and Frisch; 10°, Voyagers, such as Marcgrave, Rumphius, Sloane, Hasselquist, and Osbeck.—B. Methodists: divided into, 1°, Philosophers, such as Swammerdam, Réaumur, De Geer, and Linnæus; 2°, Systematists, the same; 3°, Nomenclators.

II. Entomophilists. 1°, Anatomists, such as Malpighi, Swammerdam, Leuwenhoeck, Lyonnet, &c.; 2°, Physicians, such as Dioscorides, Galen, Aldrovandus, Mathiolus, Glauber, Dale, &c.; 3°, Miscellanei, such as Bochart, Desser, Lerham, &c.

Then follow the systematic and analytical tables which lead to the determination of the genera and sub-genera, by the successive and compared examination of the various parts of the bodies of insects. We had the pleasure to meet Mr Brunnich in Copenhagen, a considerable number of years ago, and were interested in seeing the earliest author, if not the oldest man, among living naturalists.

J. E. Voet.—*Catalogue raisonné ou systematique du genre des Insectes qu'on appelle Coleoptrées*, 4to, Haye, 1766.—*Icones Insectorum Coleopterorum Synopsis, Observationibus Commentarioque perpetuo illustravit* D. W. F. Panzer, 4to, Erlangæ, 1794. The plates are characteristic of the species,—the letter-press is of little value.

J. R. Forster, born at Dirchaw in Polish Prussia, died in 1798, was the companion of our great circumnavigator Cook. In our present department he published *Novæ species Insectorum Centuria*, 1 vol. 8vo, Lond. 1771;—and a *Catalogue of British Insects*, 8vo, Warrington, 1770.

W. Curtis.—*Fundamenta Entomologiæ, or an Introduction to the Knowledge of Insects*, 8vo, Lond. 1772.—*Instructions for Collecting and Preserving Insects*, Ibid. 1772. *A short History of the Brown-Tail Moth, &c.*, 4to, Ibid. 1782.

Benjamin Wilkes.—*The English Moths and Butterflies, together with the Plants, Flowers, and Fruits, whereon they Feed, &c.*, 4to, fig., Lond. 1747-60.—*One hundred and twenty copperplates of English Moths and Butterflies.* 4to, Lond. 1773.

Thomas P. Yates.—*Institutions of Entomology, &c.*, 8vo, Lond. 1773.

Peter Simon Pallas, one of the greatest zoologists of modern times, was born at Berlin in 1741, and died in 1812. He was a copious writer, but his only entomological work with which we are acquainted is the *Icones Insectorum, præsertim Rossiæ Siberiæque peculiarum*, published in a small 4to volume at Erlangen in 1781. He spent most of his life under the patronage of the Russian government.

D. Drury, an English goldsmith, collected a fine cabinet of insects, and published a work in 3 vols. 4to, entitled *Illustrations of Natural History*, 1770-82. It has scarcely been surpassed in beauty, and accuracy of execution, even by the more sumptuous efforts of the present day. The figures are by Moses Harris. There is a new edition with notes by Mr Westwood, Lond. 1837.

Marie Dominique Joseph Engramelle, an Augustine friar of Paris, was born in 1727, and died in 1780. He is known as the author of the descriptive portion of a noted work,—*Collection des Chenilles, Crysalides, et Papillons, qui se trouvent en Europe, peints d'après nature*, 8 vols. 4to, and Suppl., Paris, 1779-93. The text is held in no great estimation, but the plates are faithful, and generally represent the species in their various states. They were executed after drawings by Ernst, an artisan of Strasburg, who possessed an extraordinary and self-acquired talent for the representation of lepidopterous insects.

Peter Cramer, a merchant of Amsterdam, was the author of another magnificent work on Lepidoptera, entitled *Papillons exotiques des trois parties du Monde, l'Asie, l'Afrique, et l'Amerique.* It is written in Dutch and French, consists of 4 vols. 4to, and contains 400 coloured plates. Dated from 1779 to 1782. There is a supplementary volume to the above by Casper Stoll, a Dutch physician. It was published at Amsterdam (in Dutch and French) in 1 vol. 4to, 1790 *et seq.*, and contains many interesting representations of insects in their larva and pupa states. In execution these works are inferior to those of Harris, but they are nevertheless highly esteemed by amateurs of books in natural history.

John Christian Fabricius, a pupil of Linnæus, and professor of natural history and rural economy at Kiel, in Holstein, was born at Tundern, in the duchy of Sleswick, in 1742, and died in 1807. He was one of the greatest entomologists of modern times, and published numerous

systematic works on insects. The important influence which his writings exercised on the science renders it desirable that we should present an account, however brief, of his performances, and of the principles on which they were conceived and executed.

The entomological system of Fabricius is founded on the number, proportion, form, and situation of the parts which constitute the mouth of insects, and is hence not unfrequently known under the name of the *cibarian* or *maxillary* system. His intention appears to have been to effect for entomology what his great master had done for botany, by erecting his system upon a fixed and restricted foundation; and as Linnæus had assumed the fructification of plants for his botanical basis, so the entomologist of Kiel, perceiving no doubt how important was the employment of the teeth and jaws in the classification of the vertebrated tribes, determined to make use of the analogous organs, so much more varied and numerous in the insect world. De Geer had previously employed the parts of the mouth, in addition to the organs of flight; but Fabricius followed out the system both more minutely and with greater extension, and adopted the *trophi*, or parts of the mouth, as the sole support of his superstructure. "Though nothing," observes Mr Kirby, "seems to have been farther from his intention than to follow *Nature*, since he complains that Linné, by following her too closely, had lost the Ariadnean thread of system, yet it is singular that, by building upon this seemingly narrow foundation, he has furnished a clue, by the due use of which, instead of deserting her, his successors have been enabled with more certainty to extricate her groups; since the parts in question, being intimately connected with the functions and economy of these animals, where they differ materially, indicate a corresponding difference in their character and station."

The foundations of this new system were first exhibited in his *Systema Entomologiæ, sistens Insectorum classes, ordines, genera, et species*, 1 vol. 8vo, 1775. In the ensuing year he published his *Genera Insectorum*, and his *Philosophia Entomologica* appeared in 1778. In 1781 he put forth his *Species Insectorum*, in 2 vols. 8vo; and to these, at an after period, was added a kind of supplement, with the title of *Mantissa Insectorum, sistens eorum species nuper detectas*, likewise in two 8vo volumes. From 1792 to 1796 he published the same works, remodelled and amended, under the name of *Entomologia systematica emendata et aucta*, 4 vols. 8vo; and to these a supplementary volume was added in 1798. His systems of the different orders, or *classes*, as he has chosen to name the primary groups, then made their appearance, each in a separate form, according to the following titles and dates: *Systema Eleutheratorum* (Coleoptera), 2 vols. 8vo, 1801; *Systema Rhyngotorum* (Hemiptera), 1 vol. 8vo, same year; *Systema Piezatorum* (Hymenoptera), 1 vol. 8vo, 1804; *Systema Antliatorum* (Diptera), 1 vol. 8vo, 1805. The *Systema Glossatorum* (Lepidoptera) was on the eve of publication when the author was removed from his accustomed sphere of action, and called to that tribunal which awaits entomologists in common with other men. Illiger has given us an extract from it in his *Magazin fur Insectenkunde*, and the English reader will find it exhibited in the *Philosophical Magazine and Annals* for February 1830. The publication of so great a number of works proves the devoted constancy of the author, and his unweared desire to perfect his favourite department of science.

E. J. C. Esper, professor at Erlangen, published, from 1777 to 1807, a great work on the Lepidoptera of Europe, under the name of *Europäischen Schmetterlinge*, 5 vols. 4to, of which the first and fourth are divided into two. The figures are exact and well coloured, and although the publication was never brought to a conclusion, it is highly prized by naturalists, even in its incompleted state. He is likewise the author of *Die Auslandischen Schmetterlinge*, 4to, fig. col. Erlang. 1785–98. (Reprinted, Erlang. 1830–34.)

Caspar Stoll, formerly mentioned as the author of a *Supplement* to Cramer's *Papillons Exotiques*, also published some excellent figures of hemipterous and orthopterous species. His *Représentation exactment coloriée d'après Nature, des Spectres, des Mantes, des Sauterelles*, &c. consists of eight numbers 4to (Dutch and French), 1787, *et seq.* There are ten numbers of his other work, entitled *Représentation exactment colorieé d'après Nature, des Cigales et des Punaises*, 4to, fig. Amsterd. 1780–83. These two works are of great value, on account of the figures of the very singular tribes of which they treat; but the letterpress is defective in point of observation, and faulty in its synonyms.

Moses Harris, an English painter, and naturalist of the old school, is known as the author of *An Exposition of English Insects*, in English and French, 1 vol. 4to, with coloured figures, London, 1781. He also wrote *The Aurelian, or Natural History of English Insects, namely, Moths and Butterflies*, folio, Lond. 1778; and was the author of an earlier and more portable volume, entitled *The English Lepidoptera, or the Aurelian's Pocket Companion*, 8vo, Lond. 1775. Harris was a first-rate entomological artist.

F. de P. Schrank, a Bavarian naturalist, born in 1747, professor at Ingoldstadt, published, under the unassuming title of a catalogue of Austrian insects, *Enumeratio Insectorum Austriæ Indigenorum*, a large octavo volume, in 1781. This work is remarkable for a careful synonymy, and the exactness of its descriptions. The Lepidoptera are intentionally omitted, that order having been taken up, over the same territory, by Schrank's compatriot Schiffermüller.

I. N. de Laicharting, professor at Inspruck, born in 1747, wrote upon the insects of Tyrol, *Verzeichniss der Tyrolen Insecten.* 2 vols. 8vo, with plates, Zurich, 1781–4. It appears to contain only Coleoptera.

Dominique Cyrillo, a Neapolitan physician, unfortunately executed for a misdemeanour in 1796, was the author of a work in 1 vol. folio, with coloured plates, entitled *Entomologiæ Neapolitanæ specimen.* 1787.

Vincent Petagna, another Neapolitan, composed a work on the *Elements of Zoology.* 2 vols. 8vo. He also wrote *Specimen Insectorum Ulterioris Calabriæ.* 4to, Frankfort, 1787.

Schiffermuller. *Ankundigung eines Systematischen Werkes von den Schmetterlinge der Wiener Gegend.* 4to, Wien, 1775.

J. A. Ben. Bergstrasser. *Entomologia Erxlebiana Scholarum in usum concinnata.* 8vo, Hanau, 1776.—*Nomenclatur u. Beschreib. der Insekten in der Grafschaft Hanau-Münzenborg, &c.* 4to, fig. Ibid., 1778, 8vo.—*Icones Papilionum diurnorum quotquot adhuc in Europâ occurrunt, descriptæ*, &c. 4to, Ibid., 1779–81.

James Barbut. *The Genera Insectorum of Linnæus, exemplified by various Specimens of English Insects.* 4to, fig. col. Lond. 1781.

Charles de Villiers. *Les Insectes de France décrits et classés selon la Méthode de Linnæus, déssinés par Genichon, et gravés par les plus célébres Artistes.* 4 vol. 4to, Lyon, 1781–83.—*Nomenclator iconum Entomologiæ Linneanæ.* Fol.—*Linnæi Entomologia, Speciebus nuperrimé detectis locupletata.* 4 vols. 8vo, Lugd., 1787.—*C. Linnæi Entomologia Faunæ Suecicæ descriptione aucta.* 4 vols. 8vo, Lugd., 1789.

G. Fr. Ahrens. *Verzeichniss einiger Schmetterlinge, &c.* Halle, 1783.

C. G. Jablonsky. *Natursystem aller bekansiten in- und Auslandischen Insekten*, &c. 8vo. Berlin, 1783–1806.

Gabr. Bondsdorff. *Historia Naturalis Curculionum*

Sueciæ. 4to, fig. Upsal, 1785. We owe to this author various dissertations on the senses and physiology of insects.

A. F. Fourcroy. *Entomologia Parisiensis, sive Catalogus Insectorum quæ in agro Parisiensi reperiuntur.* 2 vols. 8vo, Paris, 1785.

N. Amoreux. *Notice sur les Insectes de la France reputés vénimeux.* 8vo, Paris, 1789.

John Charles Roemer is the compiler of *Genera Insectorum Linnæi et Fabricii iconibus illustrata.* 1 vol. 4to, 1789. This is chiefly a revised edition of Sulzer's *Kenzeichen der Insecten*, with some additional plates.

Nic. J. Brahm. *Handbuch der ökonomischen Insectengeschichte, in Form eines Kalenders bearbeitet.* 2 vols. 8vo, Mainz, 1791.—*Versuch einer Fauna Entomologica der Gegend. um Mainz.* 8vo, Giesen, 1793.

Spir. Giorno. *Calendario Entomologica.* 8vo, Torino, 1791.—*Memoria Entomologica*, &c. 8vo, Ibid., 1791.

Th. Martyn. *The English Entomologist, exhibiting all the Coleopterous Insects found in England, including upwards of* 500 *species, arranged*, &c. 4to, Lond., 1792.—*Psyche; Figures of nondescript Lepidopterous Insects.* 4to, Ibid., 1793.

E. J. C. Esper. *Magazin der neuen ausländischen Insekten.* Erlang., 1794.—*Die ausländischen Schmetterlinge.* 4to. fig. 1785–98.

Fr. Weber. *Nomenclatur Entomologicus secundum Fabricii Systema.* 8vo, Hamb., 1795.—*Observationes Entomologicæ.* 8vo, Kiliæ, 1795–1801.

John Francillon. *Description of a rare Scarabæus from Potosi, &c.* 4to, fig. Lond., 1795.—*Catalogue of the Collection of Foreign Insects.* 8vo, Lond., 1818.

J. G. Kugellan, und J. K. W. Illiger. *Verzeichniss der Käfer Preussens, &c.* 8vo, Halle, 1798.

Carl Peter Thunberg, a noted naturalist and traveller, has contributed greatly to our knowledge of northern insects, and of many others. He was a favourite disciple of Linnæus, and evinced a strong predilection for the study of nature at an early age. He was the son of a Swedish clergyman, and obtained pecuniary assistance from his friends to enable him to proceed upon his travels. After visiting France and Holland, he journeyed to the Cape, Ceylon, Java, and Japan, and brought back from those far countries many new and rare forms both of plants and insects. On returning to the land of his nativity he became professor at Upsal, was made a knight of the order of Vasa, and enjoyed his honours to a very advanced age. We shall name a few of his works. Many of his papers are in the *Mémoires* of the Academy of St Petersburg, and in the *Acts* of the Society of Upsal. *Dissertatio Entomologica, novas Insectorum species sistens.* 4to, fig. Ups., 1782–91.—*Dissertatio Entomologica, sistens Insecta Sueciæ.* 4to, Ups., 1784–95.—*Characteres Generum Insectorum.* 4to, Ups., 1789, 12mo, Gott., 1791.—*Descriptiones Insectorum Suecicorum.* 5 vols. 4to, fig. Ups. 1792.

Pietro Rossi, an Italian naturalist, professor at Pisa, composed the *Fauna Etrusca, sistens Insecta quæ in Provinciis Florentina et Pisana præsertim collegit* Petrus Rossius, &c., 2 vols. in 4to, with coloured plates, Liburn. 1790;—also *Mantissa Insectorum, exhibens species nuper in Etruria collectas* a Petro Rossio, &c. 2 vols. 4to, with coloured plates. Pisa, 1792–1794.

Antoine Guillaume Olivier, member of the Academy of Sciences, professor of zoology at the veterinary school of Alfort, was born at Draguignan in 1756, and died in 1814. Besides his *Voyage dans l'Empire Ottoman, l'Egypte, et la Perse*, 3 vols. 4to, 1807, he wrote two important works on entomology:—1*st*, The subject *Insectes*, of the *Encyclopédie Méthodique*, 4 vols. 4to. In this voluminous article he follows the principles of the Linnæan classification, with certain modifications from the works of Geoffroy, Schœffer, and De Geer. He draws his primary characters from the number and consistence of the wings and elytra, and he then makes use of the wings, along with the parts of the mouth and the articulations of the tarsi, for his secondary subdivisions. The following is his nomenclature and arrangement of the orders:—Lepidoptera, Neuroptera, Hymenoptera, Hemiptera, Orthoptera (this is his own denomination, now generally received, and substituted by Olivier for the term Dermaptera used by De Geer), Coleoptera, Diptera, and Aptera. Each of these orders is divided into many sections. In the last-named order are comprehended all those insects of which the mouth is variable, but which have no wings in either sex. Of these some have six feet (pediculi), others eight (spiders)—while many (such as crabs and Julidæ) have a still greater number. We may here note, in regard to the entomological portion of the *Encyclopédie Méthodique*, that several other authors have contributed to its later volumes. Of these we may name more particularly MM. Adolphe Brongniart, Latreille, Lepelletier de St Fargeau, De Serville, Desmarets, and Godard. 2*d*, The other great work of Olivier is the *Histoire Naturelle des Coléoptères*, in six large 4to volumes, containing 363 coloured plates, and 3162 historical and descriptive pages. It appeared at intervals from 1789 to 1808. It is a work of authority, ably executed, and professes to describe and figure all the known species of the period. Vast additions have been made to entomology since the time of its conclusion, but it still presents the largest collection of coloured representations of the coleopterous order which we yet possess. In the later portions, the number of species in certain genera having greatly increased, the author was obliged to depart from his original plan of including all the known kinds. This is chiefly perceptible in the great families of *Curculionidæ* and *Chrysomelidæ*.

John Daniel Preysler wrote *Werzeichniss Boehmischer Insecten.* 1 vol. 4to, Prag. 1790.

John Berkenhout, M.D., in his *Synopsis of the Natural History of Great Britain and Ireland*, 2 vols. 8vo, Lond. 1795, enumerates our native insects.

William Lewin, F.L.S. was the author of *The Papilios of Great Britain systematically arranged, and painted from Nature.* 1 vol. 4to, Lond. 1795.—*A Natural History of the Lepidopterous Insects of New South Wales.* 4to, col. fig. Lond., 1805.

David Henry Hoppe, an apothecary of Ratisbon, was the author of *Enumeratio Insectorum elytratorum indigenorum*, with coloured plates, Erlangæ, 1795,—a work with which we are not acquainted, but which is said to be a useful auxiliary in the study of the genus *Donacia.* He also published *Insecta Coleoptera, quæ in itineribus suis præsertim Alpinis collegerunt.* Nov. Act. Nat. Cur. xii. p. 479. The latter work is in conjunction with Dr Hornschuch.

John Abbot. *The Natural History of the rarer Lepidopterous Insects of Georgia, collected from the Drawings and Observations of Mr John Abbot.* 2 vols. fol., Lond., 1797. This work was brought out by Sir James Edward Smith, the great Linnæan botanist. The plates are by Moses Harris, and are characterized by Mr Swainson as the last and best of that artist's performance.

Leonard de Prunner is the author of *Lepidoptera Pedemontana.* 1 vol. 8vo, Turin, 1798.

Antoine Jean Coquebert, a naturalist established at Rheims, besides various notices in the *Bulletin des Sciences*, is known as the author of *Illustratio iconographica Insectorum quæ in Musæis Parisinis observavit*, J. Chr. Fabricius. 3 decad. in 4to, Paris, 1799–1804.

Christian Creutzer published Entomological Essays, in German (*Entomologische versuche*), 8vo, with coloured figures, Vienna, 1799.

Pierre-André Latreille, of the Royal Academy of

Sciences, &c., was born at Brives in 1762, and died in 1833. The importance attached to the numerous productions of this "Prince of Entomologists," as he is called by Comte Dejean, inclines us to present the reader with a short historical sketch of the principles and progressive improvement of his system, in combination with our chronological notice of his various volumes.

Latreille's first work was published at Brives in 1796, under the title of *Precis des charactères generiques des Insectes, disposés dans un order naturel*, 1 vol. 8vo. He there divides the insecta of Linnæus into fourteen classes, of which the first seven comprehend such as are *winged*, and are ranged in the following orders: Coleoptera, Orthoptera, Hemiptera, Neuroptera, Hymenoptera, Lepidoptera, and Diptera. The other seven classes are apterous, or without wings, and are named and characterized as follows: 1°, Les Suceurs, *Suctoria* (Rhyngota of Fabricius),—head distinct, antenniferous, trunk articulated, inclosing a sucker of two bristles; two scales at the base; six feet: 2°, Les Thysanoures, *Thysanoura* (Synistata of Fab.),—head distinct, antenniferous; mouth furnished with mandibles, a pair of maxillæ, an upper and an under lip, and antennulæ (palpi); six feet;—here are ranged Lepisma, Forbicina, and Podura: 3°, Les Parasites, *Parisiti* (Antliata, Fab.),—head distinct, antenniferous; a very short tube inclosing a sucker; in some a slight appearance of mandibles or maxillæ; six feet;—Ricinus and Pediculus: 4°, Les Acéphales, *Acephala* (Unogata et Antliata of Fab.),—organs of the mouth appearing to replace the head; no antennæ; from six to eight feet (this is the class since distinguished by the name of Arachnides, and already discussed under that title in this Encyclopædia): 5°, Les Entomostracés, *Entomostraca* of Müller (Synistata et Agonata, Fab.),—head confounded with the body, which is inclined under a covering of one or two pieces; antennæ frequently branched, mandibles without antennulæ; two ranges at most of maxillary leaflets; no under lip; generally from six to eight feet;—Monoculus, Cypris, Cytherea, Daphnia, Argulus, Limulus, &c.: 6°, Les Crustacés, *Crustacea* (Agonata, Fab.),—head confounded with the body, which is usually inclosed beneath a carapace; four antennæ; many ranges of maxillary leaflets, of which two are inserted and couched upon the mandibles; no lips; generally ten feet: 7°, Les Myriapodes, *Myriapoda* (Synistata, Mitosata, Unogata, Fab.),—head distinct from the body, antenniferous; mandibles with a conical advancement at their base; scaly teeth implanted on the contour of the extremity; two rows of maxillæ at most; an under lip; fourteen feet, or more;—Asellus, Cyamus, Oniscus, Julus, Scolopendra.

Latreille's next publication was the *Histoire générale et particulière des Crustacès et des Insectes*, 14 vols. 8vo, with figures, 1802–5. It forms a portion of the edition of Buffon's works published by Sonnini. His *Genera Crustaceorum et Insectorum*, 4 vols. 8vo, was published in 1806–7, and contains a further, and certainly very skilful development of what he regarded as a natural system. In 1810 appeared his *Considerations générales sur l'ordre naturel des animaux composant les classes des Crustacés, des Arachnides, et des Insectes, avec un tableau methodique de leurs genres distribués en familles*, 1 vol. in 8vo. It may be regarded as a review of his last-mentioned work, of the material parts of which it proposes few alterations,—but the groups are fewer in number, and are sometimes founded on more rigorous characters. We shall here give a brief abstract of his classification at this time. The Linnæan class Insecta is divided into three distinct classes—Crustacea, Arachnides, and Insects properly so called. It is of course with the latter only that we are now concerned. He divides them into eight orders—Coleoptera, Orthoptera, Hemiptera, Neuroptera, Hymenoptera, Lepidoptera, Diptera, and Suctoria.

1st, The Coleoptera are divided into five sections: 1. *Pentamera*, including nineteen families, viz. Cicindeletæ, Carabici, Hydrocanthari, Gyrinites, Sternoxi, Malacodermi, Clerii, Necrophagi, Staphylinii, Palpatores, Ptiniores, Dermestini, Byrrhii, Hydrophilii, Sphæridiota, Coprophagi, Geotrupini, Scarabæides, and Lucanides: 2. *Heteromera*, including six families, viz. Pimeliariæ, Tenebrionites, Pyrochroides, Mordellonæ, Cantharidiæ, and Œdemeritæ: 3. *Tetramera*, including ten families, viz. Bruchelæ, Curculionites, Bostrichini, Paussili, Xylophagi, Cucujupes, Cerambycini, Criocerides, Chrysomelinæ, and Erotylenæ: 4. *Trimera*, including the family of Coccinellidæ: 5. *Dimera*, including that of the Pselaphii.

2d, The order Orthoptera contains six families, viz. Forficulariæ, Blattariæ, Mantides, Gryllides, Locustariæ, and Acrydii.

3d, The order Hemiptera is composed of two sections: 1. *Heteroptera*, containing the three families, Corisiæ, Cimicides, and Hydrocorisæ: 2. *Homoptera*, containing the four families of Cicadariæ, Psillidæ, Aphidii, and Gallinsecta.

4th, The order Neuroptera is likewise bisected: 1. *Subulicornes*, consisting of two families, Libellulinæ, Ephemerinæ: 2. *Filicornes*, consisting of nine families, Panorpatæ, Myrmeleonides, Hemerobini, Megaloptera, Raphidinæ, Termitinæ, Psoquillæ, Perlariæ, and Phryganites.

5th, The order Hymenoptera also forms two sections: 1. *Terebrantia*, including eight families, viz. Tenthredinetæ, Urocerata, Evaniales, Ichneumonides, Diplolepariæ, Cynipsera, Proctotrupii, and Chrysidides: 2. *Aculeata*, including thirteen families, viz. Formicariæ, Mutillariæ, Scolietæ, Sapygitæ, Pompilii, Sphegimæ, Bembecides, Larratæ, Crabronites, Vespiariæ, Masarides, Andrenetæ, and Apiariæ.

6th, The order Lepidoptera is divided into three sections: 1. *Diurna*, composed of two families, Papilionides and Hesperides: 2. *Crepuscularia*, also composed of two families, Sphingides and Zygenides: 3. *Nocturna*, composed of eight families, Bombycites, Noctuo-bombycites, Teneites, Noctuælites, Phalænites, Pyralites, Crambites, and Pterophorites.

7th, The order Diptera comprises three sections: 1. *Proboscidea*, consisting of fourteen families, Tipulariæ, Stratiomydæ, Tabani, Rhagionides, Dolichopodes, Mydasii, Asilici, Empides, Anthracii, Bombyliarii, Inflata, Syrphiæ, Conopsariæ, Muscides: 2. *Eproboscidea*, containing the family Coriacea: 3. *Pthiromyiæ*, including merely the genus Nycteribia.

8th, The order Suctoria is formed entirely by the genus Pulex.

In the year 1817 the *Règne Animal distribué d'après son organisation*, &c. was published by Baron Cuvier, in 4 vols. 8vo. Of that signal work the entomological portion, forming volume third, was contributed by M. Latreille. In addition to the preceding works, he had also at different times contributed a great proportion of the articles on entomology in the first and second editions of the *Nouveau Dictionnaire d'Histoire Naturelle.* One of his earlier works is entitled *Essais sur l'Histoire des Fourmis de la France*, Brives, 1798. He was likewise the author of many papers in the *Annales du Muséum*, the *Encyclopédie Méthodique*, and in the *Dictionnaire Classique d'Histoire Naturelle*, as well as of a separate volume of papers (chiefly, however, extracted from his previous labours in the *Ann. du Mus.*) entitled *Mémoires sur divers sujets de l'Histoire Naturelle des Insectes*, &c. &c., 8vo, 1819. In 1825 he published his *Familles Naturelles du Règne Animal*, which contains a compendious summary of zoological classification, and an arrangement of the insect tribes. In 1829 he gave to the world his completed views on entomological arrangement in the third and fourth volumes of the second edition of the

Bibliography.

Règne Animal of Cuvier. As it is by this final exposition that we are chiefly guided in the systematic portion of the ensuing treatise, we need not here enter into further details. Before proceeding, however, with our catalogue of authors, we may remark that an excellent, and, we believe, novel feature in the system of Latreille consists in the bestowal of family names upon the groups of genera. The modern families correspond in numerous instances to the old and undivided genera of Linnæus; and when, in the progress of improvement, and the great increase in the number and nature of species, it became necessary to subdivide these genera into others of a less comprehensive character, the retention of the old generic name with a different termination, and its application as a comprehensive term to all the cognate genera, was an ingenious and useful device.

The practice, indeed, was previously well known in other departments of natural history, but it does not appear to have been properly applied to entomology prior to the example of Latreille. There is a want of uniformity, however, in the nomenclature of his families, so that, unless his work is kept in hand, we cannot ascertain from the name of a group whether it signifies an actual family, or some other sectional division. To remedy this defect, Mr Macleay, in his *Horæ Entomologicæ*, follows the suggestion of Mr Kirby, and designates his family groups by the patronymic termination in *idæ*, which, though not classically correct when the primitive has a feminine termination, is preferable to any other plan, both for uniformity's sake, and *euphoniæ gratia*. The latest works by M. Latreille with which we are acquainted are his *Cours d'Entomologie*, an uncompleted publication, in one volume 8vo, 1831, and his *Discours a La Societé Entomologique de France*, 8vo, Paris, 1832.

George Wolfgang Francis Panzer of Nuremberg, born in 1755, is the author of several excellent works on Entomology, of which the earliest is the most important. It is called *Deutschlands Insekten*, or *Faunæ Insectorum Germaniæ initia*, and has continued to be published at intervals between the years 1793 and 1841. It is composed of numerous *cahiers*, or small collections of unstitched leaves, each of which corresponds to a coloured plate of an insect, of which it bears the description. According to this plan, the figures and letter-press may be arranged according to any system preferred by the possessor of the work. Each fasciculus contains the figures and descriptions of twenty-four species of insects; and as the fasciculi (continued since the 110th, by G. A. W. Herrich-Schäffer) now amount to 190, the total number represented and described is great. It is consequently one of the most extensive collections which we possess in this branch of science; and as the plates are extremely correct, and the synonyms carefully selected, it may be regarded as a publication of the highest value of its kind. "The figures are drawn and etched by the famous Sturm, the best entomological artist on the Continent, and are simply but accurately coloured,—while the descriptions, although frequently too short, are written by the hand of a master." (Swainson.) Panzer has published several other works on insects.—*Novæ Insectorum species*, &c., Norimb., 1790.—*Faunæ Insectorum Americæ borealis Prodromus*, 4to, Norimb., 1794.—*Kritische Revision der Insektenfauna Deutschlands*. 8vo, Nürnb., 1805–7.—*Entomologischen versuch über die Jurineschen Gattungen der Linneischen Hymenoptern*. 1 vol. in 12mo, 1806.—*Index Entomologicus, pars prima, Eleutherata*, same form, 1813. This author has confined himself to the description of the external aspect of insects, and does not appear to have devoted himself at any time to the observance of manners, or the examination of internal structure. Non omnia possumus omnes.

Augustus William Knock, a professor at Brunswick, formed a collection of insects, which now composes a portion of the Royal Museum of Berlin. He is author of *Neue beytræge zur Insectenkunde*. 1 vol. in 8vo, with figures, Leipsic, 1801.

James Henry Laspeyres, a municipal officer of Berlin, composed a work entitled *Sesiæ Europeæ iconibus et descriptionibus illustratæ*. 1 vol. 4to, 1801. He is likewise the author of *Critical Observations on the Systematic Catalogue of the Lepidoptera of the environs of Vienna*, inserted in Illiger's *Magazin*.

Jacques Sturm was an entomological artist of repute, and an excellent observer of insects. We owe to him the following works:—*Insecten-kabinet*, 12mo, Nürnb., 1791–92.—*Verzeichniss meiner Insecten-Samlung, oder Entomologisches Handbuch fur Liebhaber u. Sammler*. 8vo, fig. Nurnb., 1800.—*Abbildungen zu Illigers Uebersetzung*, von Olivier's *Entomologie, oder Nuturgeschichte der Insecten*. 2 vols. 4to, Nûrnb., 1802-3.—*Entomologische Hefte, enthaltend Beiträge zur weitern Kenntniss und Aufklarung der Insektengeschichte*. 2 vols. 8vo, fig. Frankfort, 1803.—*Catalog meiner Insecten Samlung*. I. Th. Käfar, 8vo, fig. col. Nurnb., 1825.—*Anophthalmus* (*Blindlaufkäfer*) *neue Gatlung aus der Familie du Caraben*. 8vo. Nurnb., 1844.

Clairville, an Englishman, as we understand, by birth, but an inhabitant of Switzerland, published a work in French and German, called *Entomologie Helvetique*, 2 vols. 8vo, with excellent figures. Indeed Schellenberg the engraver was his colleague in the undertaking. Both volumes were printed at Zurich, the first in 1798, the second in 1806. The chief defect of this work consists in the entire and unnecessary change in the nomenclature of his predecessors, affected by the author, as will be seen by the following analytical table of his systematic arrangement. We add the ordinary names of the orders, which he is pleased to regard in the light of sectional divisions.

			Sections.
Insecta	Pterophora, winged.	Mandibulata.	1. Elytroptera: crustaceous wings. (Coleoptera.)
			2. Deratoptera: coriaceous wings. (Orthoptera.)
			3. Dictyoptera: reticulated wings. (Neuroptera.)
			4. Phleboptera: veined wings. (Hymenoptera.)
		Haustellata.	5. Halteriptera: wings with poisers. (Diptera.)
			6. Lepidioptera: scaly wings. (Lepidoptera.)
			7. Hemimeroptera: mixed wings. (Hemiptera.)
	Aptera, wingless.	Haustellata.	8. Rophoteira: suckers.
		Mandibulata.	9. Pododuuera: runners.

Clairville's work is not complete in the description of genera and species. The first volume, indeed, contains only the coleopterous family of the Curculionidæ, and is furnished with sixteen plates illustrative of eleven genera. It is a minutely laboured publication, beautifully executed, but more sumptuous than accurate in its typography.

J. Fr. W. Herbst, a preacher at Berlin, born 1743. *Kurze Einleitung zur Kenntniss der Insecten*, &c. 3 vols. 8vo, Berl., 1784–87.—*Genres des Mouches Diptères*. 2 vols. 8vo, Zurich, 1802. Conjointly with C. G. Jabonsky, Herbst has published *Natursystem in-und Ausländischer Insekten*, in 21 vols. 8vo. Schmetterlinge, 11 vols. Berl., 1783–1804. Käfer, 10 vols. Ibid., 1785–1806.

Joh. Casp. Fuessli was the author of *Magazin für die Liebhaber der Entomologie*. 2 vols. 8vo, Zur. 1758-9.—*Neue Magazin für die Liebhaber*, &c., 3 vols. 8vo, Ib., 1782–87 *Archiv der Insectengeschichte*. 4to, Ib., 1781–86. There i a French translation with same plates. Winterthom, 1794

William Lewin, F.L.S., contributed to Entomology *The Insects of Great Britain*, 1 vol. 4to, London, 1795. It contains the *Papiliones* only.

Frederick Weber, a German naturalist, and professor at Kiel, wrote *Observationes Entomologicæ*, 1 vol. 8vo, Kiel, 1801.

J. C. G. Illiger, professor at Berlin, an excellent naturalist, who died in early life. He terminated the catalogue of Prussian insects commenced by Theophilus Kugelann, under the title of *Verzeichniss der Kæfer Preussens*, 1 vol. 8vo, 1798. Between 1801 and 1807 he published the *Magazin fur Insectenkunde*, 7 vols. 8vo; and during that first-mentioned year his *Systematisches Verzeichniss von den Schmetterlingen der Wiener gegend*, in two vols. 8vo, likewise made its appearance. It is a revised edition of the systematic catalogue of the environs of Vienna. Illiger continued the edition of the *Fauna Etrusca* of Rossi, commenced by Hellwig, in 8vo, Helmstadt, 1807.

John Frederick Wolff, a German physician, has published four fasciculi of a work entitled *Icones Cimicum descriptionibus illustratæ*, in 4to, Erlangæ, 1804.

Thomas Marsham, an English entomologist, is well known as the author of *Entomologia Britannica, sistens Insecta Britanniæ indigena secundum methodum Linnæanam disposita*, t. 1, Coleoptera, 8vo, Lond. 1802. It is a meritorious publication for the period, and has been serviceable to the science; but prodigious advances have been made in all the departments of British Entomology since the time of its appearance. Marsham also published a *Monograph of the genus Notoclea*, in the 9th vol. of the *Linn. Trans.* These insects are peculiar to New Holland, and are now better known under the name of *Paropsis*, bestowed upon them by Olivier.

William Kirby, A.M., &c., author of *Monographia Apum Angliæ*, 2 vols. 8vo, Ipswich, 1802, and (jointly with Mr Spence) of *Introduction to Entomology*, 4 vols. 8vo, London, 1815–26. These admirable works are too well known to require our praise. The latter has been the chief means of producing whatever may exist of a *general* taste for Entomology in Britain.—*Fauna Boreali Americana* (Insects). 4to, fig. ed. Ipsw., 1837.—*The genus Apion of Herbst's Natursystem considered*, &c. *Linn. Trans.* vol. 9th, p. 1.—*Strepsiptera, a new order of Insects proposed, and the characters of the order, with those of its genera, laid down.* Vol. 11th, p. 86.—*A Century of Insects, including several new genera*, &c.—*A description of several new species of Insects collected in New Holland.* Ibid. vol. 12th, pp. 375–454. This venerable and truly "good old man," the father of modern Entomologists, died on the 4th of July 1850, aged *ninety-one* years. He had been the resident minister of Barham for sixty-eight years, and so we presume may have been regarded as the father of the Church of England. He was president of the Ipswich museum, an institution in which, from its commencement, he took a lively interest. Of late years he had been obliged to retire from active life, whether clerical or scientific.

William Spence, F.L.S., &c., Mr Kirby's able and accomplished coadjutor in the principal work above named, is also the author of various minor essays in entomology, of which we shall name merely his *Monograph of the British species of the genus Choleva. Linn. Trans.* vol. 11th, p. 123.

Adrian Hardy Haworth was the author of *Prodromus Lepidopterorum Britannicorum*, 4to, Holt., 1802.—*Lepidoptera Britannica sistens digestionem*, &c. 4 vols. 8vo, 1803–1827; and of several contributions to the *Trans. Ent. Soc.*, &c.

J. R. Schellenberg, a painter and engraver of Zurich, is known to entomologists as professionally connected with two works, of which the text is anonymous. *Cimicum in Helvetiæ aquis et terris degens genus.* 1 vol. 8vo, with figures, Turici, 1800.—*Genres des Mouches diptères.* 1 vol. 8vo, in French and German, with coloured plates, Zurich, 1803. He was likewise artistically employed on the *Entomologie Helvétique, ou Catalogue des Insectes de la Süisse* (of which the letterpress is by M. de Clairville). 2 vols. 8vo, Zurich, 1798–1806.

John William Lewin, an English painter, son of William Lewin already mentioned, published a *Natural History of Lepidopterous Insects of New South Wales.* 1 vol. 4to, with coloured plates, London, 1805.

Gaspard Duftschmid has published descriptions of numerous families of Coleoptera in his *Fauna Austriæ*, 2 vols. 1805–25.

A. A. H. Lichtenstein, a professor of oriental languages at Hamburg, published *A Dissertation on Two Natural Genera hitherto confounded under the name of Mantis*, in the 6th vol. of the *Linn. Trans.*

Palisot, Baron de Beauvois, of the Academy of Sciences, was born in 1755, and died in 1820. He is the author of a handsome work in folio, with coloured plates, entitled *Insectes recueillis en Afrique et en Amerique*, &c. Paris, 1805 *et seq.*

Henry Smeathman has published a *History of the Termites or White Ants*, in the 71st volume of the *Philosophical Transactions.*

Christian Steven, director of the imperial botanic garden of Odessa, has published a *Description de quelques Insectes de Caucase et de la Russie Meridionale*, in the *Mém. de la Soc. Imper. des Naturalistes de Moscou*, t. ii.

—— Baumhauer. *Novelle Classification des Mouches à deux ailes.* 8vo, Paris, 1800.

C. L. v. Muller. *Entomologisches Tasken-buch für Schmetterlinges Sammler.* 12mo. fig. Bresl. 1800.—*Fauna Lepidopterorum Silesiaca, &c.* Ibid. 1802.

J. Fr. Wolff. *Icones Cimicum descriptionibus illustratæ.* 4to, Erlang. 1800-11.

J. C. L. Hellwig. *Systematisches Verzeichniss von den Schmetterlingen der Weiner Gegend.* Braunschw. 1801.

A. Afzelius (and F. W. Brannius). *Achetæ Guinenses.* 4to, fig. Upsal, 1804.

Mich. Buniva. *Intorno agli Insetti nocivi.* 12mo, Torino, 1804.

G. F. Heutsch. *Epitome Entomologiæ systematicæ secundum Fabricium, &c.* 4to, Leipz. 1804.

C. Iser. *Svenk Entomologie.* 8vo, Linköp. 1806.

J. E. Arrhenius. *Monographia Cantharidum et Malachiorum Succiæ.* Lund. 1807.

Fr. A. Bonelli. *Observations Entomologiques.* 2 parts, 4to, Turin, 1809–13.—*Descrizione di sei nuove Specie d'Insetti Lepidotteri diurni della Sardegna.* 4to, fig. Torino, 1824. We have other entomological papers by this author in the Mem. of the Turin Academy.

—— Bayle Barelle. *Saggio Intorno agli Insetti nocivi ai vegetabili economici, &c.*, 8vo, Milano, 1809.—*Degli Insetti nocivi all' Uomo, alle Bestie, ed all' Agricoltura.* 12mo, Mil. 1824.

M. J. Baudet-Lafarge. *Essai sur l'Entomologie des Dép. du Puy-de-Dôme.* 8vo, Clermont, 1809.—*Monographie des Carabiques du Puy-de-Dôme.* 8vo, 1836.

A. Ahrens. *Fauna Insectorum Europæ; cura Germar et Kaulfuss.* 18mo, 20 fascic., Hallæ, 1812.—*Beitrage zu einer Monographie der rohrkafer* (*Donacia* Fabr.). 8vo, Halle, 1817.

G. H. Berglund. *Anthracides Sueciæ.* 4to, Lund. 1814.

J. J. B. Hemmer. *Raupen und Papilions Kalender.* 8vo, fig., Coburg, 1814.

F. L. P. Bracy-Clark. *An Essay on the Bots of Horses and other animals.* 4to, fig., Lond. 1815.

—— von Malinouzky. *Elementarbuch der Insectenkunde.* 8vo, Quedlinb. 1816.

Ch. Malo. *Les Papillons.* 18mo, Paris, 1816.—*Les Insectes, ou choix des plus jolis insectes de la France et des pays étrangers.* 12mo, Paris, 1818.

F. G. CHAMPNEUF. *Considerations Medicinales sur les Insectes.* 8vo, Paris, 1817.

G. KUNSTE. *Entomologische Fragmente.* 8vo, Halle, 1818.

GUSTAVUS PAYKUL, a royal councillor, and member of the academy of Stockholm, is the author of several very valuable works. His earlier publications were monographs of the genera *Carabus*, *Curculio*, and *Staphylinus*, afterwards incorporated in his *Fauna Suecica* (*Insecta*), 3 vols, 8vo, Upsal, 1800. These contain only the coleopterous tribes. The descriptions are careful and complete. Of the same author, the *Monographia Histeroidum*, 1 vol. 8vo, Upsal, 1811, is deservedly held in the highest estimation.

H. M. GAEDE has published *Beytrage zur Anatomie der Insekten*, &c. 4to, Altona, 1815.

H. T. L. REICHENBACH has published a *Monographia Pselaphorum*, one small volume, with figures, Leipsic, 1816.

JOHN WILLIAM MEIGEN, a German naturalist, has published a very complete work on European Diptera: *Beschreibung der Europäischen Zweiflügeligen Insecten.* 6 vols. 8vo, 1818-30. 2d edit. 1851. It is accompanied by coloured plates representing a species of each genus, with the details, chiefly deduced from the antennæ, of the generic characters. Meigen is, moreover, the author of—*Abbildung aller bis jetz bekannten Europäischen Zweiflügeligen Insecten.* 1 Hft. 8vo, fig., Hamm., 1830.—*Handbuch für Schmetterlingsliebhaber.* 8vo, fig., Aachen., 1827.—*Systematische Beschreibung der Europ. Schmetterlinge, mit Abbildungen.* 4to, Aachen., 1827-31.

LOUIS JURINE, professor of anatomy and surgery at Geneva, is the well-known author of the *Nouvelle Méthode de classer les Hyménoptères et les Diptères*, avec fig., Hyménoptères, tom. 1, in 4to, Geneve, 1807. His classification is based on the ramifications of the nervures of the wings, and an acquaintance with his work is indispensable to a knowledge of the Hymenoptera. He also published a memoir in 4to, entitled *Observations sur les Xenos Vesparum*, 1816; and *Observations sur les ailes des Hyménoptères*,—"ouvrage d'une admirable patience," says Latreille. The latter appeared in the 24th volume of the *Mémoires de l'Academie de Turin.*

FRANÇOIS HUBER of Geneva, born in 1750, died in 1831, the celebrated author of the *Nouvelles Observations sur les Abeilles* (2d edition), 2 vols. 8vo, 1814, was, though deprived of sight, one of the most accurate and original observers of the habits of the insect world. The second volume of the work just named is by

PIERRE HUBER, the son of the preceding. The younger Huber was also the author of *Recherches sur les Mœurs des Fourmis indigènes.* 1 vol. 8vo, 1810; and of *Observations sur les Bourdons.* The latter was published in the 6th vol. of the *Linn. Trans.*

CHARLES JOHN SCHŒNHERR, a Swede, has published a work under the name of *Synonymia Insectorum.* 3 vols. 8vo, 1806-8-17. It contains only coleopterous insects, and although not completed even in relation to those tribes, it is a work of great labour, extreme accuracy, and consequently high value. It is of indispensable service to those who desire to trace the mystified stream of synonyms, so frequently confused and contradictory among the subjects of Entomology. Schœnherr is also the author of an excellent work, entitled *Curculionidum Dispositio methodica*, 1 vol. 8vo, Leipsic, 1826; and he has very recently brought out a much more complete and extended publication on the same great tribe, under the title of *Genera et Species Curculionidum, cum Synonymia hujus familiæ.* 7 vols. 8vo, Leipz. 1834-43.

LEONARD GYLLENHAL, another noted entomologist of Sweden, is the author of a work in several parts, called *Insecta Suecica.* 1808-28. This is one of the few works on the Coleoptera which has not been left in an uncompleted state; and the great accuracy of the descriptions, expressed in language remarkable alike for precision and perspicuity, renders it a publication of the very highest value.

EDWARD DONOVAN, an English naturalist, has published a considerable variety of illustrated works on natural history. We shall here mention only his entomological productions: *An Epitome of the Natural History of the Insects of China.* 1 vol. in 4to, 1798.—*An Epitome of the Natural History of the Insects of India.* 4to, 1800–4. 2d ed. 1842.—*General Illustrations of Entomology*, part i.—*An Epitome of the Insects of Asia.* 1 vol. 4to, 1805.—*The Natural History of English Insects.* 16 vols. 8vo, 1792–1813. The preceding were valuable and praise-worthy publications for their time, though not in every respect characterized by the scientific accuracy or critical skill which distinguish so many of the entomological works of the present day.

DRAPIEZ, professor of chemistry at Brussels, has published *Mémoires sur un nouveau genus d'Insectes Coléoptères*, and *Description de quelques nouvelles espèces d'Insectes*, in the *Annales Générales des Sciences Physiques*, Paris, 1819–21.

FERDINAND OCHSENHEIMER is the author of a German work on the Lepidoptera of Europe, *Schmetterlinge von Europa*, highly esteemed for its critical accuracy and excellent descriptions of the species. The first volume was published in 8vo, at Leipsic, in 1806. The author died in 1822, leaving his work in an incompleted state, only four volumes having been published during his lifetime, the last of which appeared in 1816, consisting chiefly of an improved sketch of his arrangement, from the first to the eighty-seventh genus. Before his death, however, only the first forty-three genera were published in detail, with the characters and descriptions of their respective species; these occupy the first three volumes, the last of which terminates with the genus *Eyprepia*, for the fourth contains, besides the sketch of the arrangement, only notes concerning some of the species published in the preceding volumes. The work has been continued by M. Frederick Treitschke, and the English reader will find an abstract of it by the late J. G. Children, Esq., F.R.S., with a list of the species of each genus, and references to one or more of their respective icones, in the *Philosophical Magazine and Annals* for 1829. Where the generic characters appeared meagre or defective, Mr Children has given additional ones from the writings of other entomologists; and he has also indicated in numerous notes the new lepidopterous genera (chiefly by Stephens and Curtis), to which the British species mentioned in the text are now to be referred. We may add to the above notice that this great work on the European Lepidoptera, *Die Schmetterlinge von Europa*, the conjoined labours of Ochsenheimer and Treitschke, is, if not completed, at least terminated, and now consists of 10 vols. 8vo, Leipz. 1806–36.

JAMES HUBNER. *Sammlung Europäischer Schmetterlinge.* 5 vols. 4to, fig. col., Augsb. 1805–32.—*Geschichte Europäischer Schmetterlinge.* 4to, Augsb. 1806–34.—*Sammlung Exotischer Schmetterlinge.* 4to, fig., Augsb. 1806–34. This author was a painter of Augsburg, and his work on the European Lepidoptera is one of the most complete which we possess. It has also the advantage of being proportionally less expensive than many other illustrated volumes, and it exhibits a great variety of *Larvæ.* Hubner is the author of several other entomological works besides those named above.

CARL. FRED. FALLÉN. *Observationes Entomologicæ.* Lund. 1802–7.—*Monographia Cicadarum Sueciæ.* 8vo, Holmiæ, 1805–6.—*Monographia Cantharidum et Malachiorum Sueciæ.* 4to, Lund. 1807.—*Specimen Entomolog. novum Dipterorum disponendi methodum exhibens.* 4to, Ibid., 1810–14.—*Hydrocorides et Naucorides Sueciæ.* 4to, Ibid., 1814.—*Aribii Sueciæ*, 4to, Ibid., 1814.—*An-*

thracides Sueciæ. 4to, Ibid., 1814.—*Diptera Sueciæ descripta.* Vol. i. ii., 4to, 1814–27.—*Specimen novum Hemipter. disponendi methodum exhibens.* Ed. nov. 4to, Lund. 1823.—*Dispositio Dipterorum synoptica.* 4to, Ibid., 1817. —*Monographia Cimicum Sueciæ.* Ed. nov. 8vo, Hafniæ, 1817.—*Monographia Muscidum Sueciæ.* 4to, Lund. 1820. *Monographia Tenthredinum Sueciæ.* 4to, Ibid. 1829.—*Hemiptera Sueciæ descripta.* Parts i. to ix., 4to, Lond. Gothor. 1829 *et. seq.*—*Monographia Pompilorum Sueciæ.* 8vo, Ibid. 1829. Besides the preceding, Fallén is the author of many minor treatises on particular tribes of the Dipterous order. He was professor of Natural History in the University of Lund.

Francis Klug, M.D., of Berlin, and one of the directors of the museum there, has contributed many treatises to Entomology. Of these we may indicate the following:—*Monographia Siricum Germaniæ,* &c. 1 vol. 4to, with coloured plates, Berlin, 1803.—*A Critical Review* of the genera of Fabricius, derived from *Apis* of Linnæus, published in Illiger's *Magazin für Insectenkunde.* 1807.—*Entomologische Monographien.* 1 vol. 8vo, with figures, Berlin, 1824.—*Proscopia novum genus Insectorum Orthopterorum,* in folio, with plates.—*Entomologiæ Brazilianæ Specimen.* Dr Klug has published in German (*Bericht über, &c.*) a *Rapport* on a collection of coleopterous insects from Madagascar, 1 vol. 4to, with plates, Berlin, 1833; and he is the author of an *Entomological Annual—Jahrbucher der Insectenkunde,* of which we are acquainted with only a single volume, published at Berlin in 1834. In conjunction with Ehrenberg he has figured and described various African and Asiatic insects in *Symbolæ Physicæ,* fol., fig. col., Berlin, 1829–30; and has published several monographs of great value.

John Louis Charles Gravenhorst, of Gottingen, a skilful entomologist, has composed the following works:—*Coleoptera microptera Brunsvicensia.* 1 vol. 8vo, 1802.—*Monographia Coleopterorum micropterorum.* 1 vol. 8vo, 1806.—*Monographie du genre Ichneumon.* 1 vol. 8vo, with figures, 1814.—*Monographia Ichneumonum Pedemontæ regionis,* forming a portion of the twenty-fourth volume of the *Mém. de l'Acad. des Sciences* of Turin.—*Monographie des Ichneumons Aptères.* 1 vol. 8vo, with figures.—*Conspectus generum et familiarum Ichneumonidum,* in 4to, conjointly with Nees ab Esenbeck.—*Beitrage zur Entomologie.* 1 vol. 8vo.—Lastly, *Ichneumonologia Europæa,* in 3 large 8vo volumes, 1829, containing above 2800 pages, devoted to the Ichneumonidæ alone.

Charles Schreibers, director of the imperial cabinet of natural history at Vienna, among his other writings has given us descriptions of various *Coleopterous Insects,* with figures, in the 6th vol. of the *Linn. Trans.* 1806.

Marcel de Serres, professor of mineralogy to the Faculty of Sciences of Montpellier, has composed many excellent articles on the anatomy of insects, printed in the *Mém. du Museum* and elsewhere (see especially his observations on the *Vaisseau dorsal,* ibid. 1819), and has published a *Mémoire sur les yeux composés et les yeux lisses des Insectes,* &c. 1 vol. 8vo, with figures, 1813.

William Elford Leach, M.D., F.R.S., &c., an English naturalist of great zeal and intelligence, continued Dr Shaw's work, under the title of the *Zoological Miscellany,* 3 vols. 8vo, Lond. 1814–17. He was also the author of various elaborate treatises on insects, published in the *Linn. Trans.,* and in the British and foreign *Encyclopædias.* His enthusiasm for Entomology has been productive of an advantage to the study in this country, which has now spread insensibly far beyond the benefit directly derivable from his own particular labours. His early death was much deplored.

Nees ab Esenbeck, a noted botanist, has published *Monographie der Ichneumoniden.* 2 vols. 8vo, Stuttg. 1828. —Also *Hymenopterorum Ichneumonibus affinium Monographiæ.* Vol. 1st and 2d, Stuttgard, 1834.

C. A. Walckenaer, beside his *Faune Parisienne,* and his works on the *Aranéides,* has published *Mémoires pour servir à l'Histoire Naturelle des Abeilles solitaires.* 1 vol. 8vo, Paris, 1817.—Also *Recherches sur les insectes nuisibles à la vigne, connus des Anciens et des Modernes, et sur les moyens de s'opposer à leur ravages.* 8vo, Paris, 1835.

William Sharpe Macleay, A.M., is the author of a work named *Horæ Entomologicæ, or Essays on the Annulose Animals,* 1 vol. 8vo, in two parts, 1819–21, remarkable for its elucidation of the circular progression of affinities. It is a production of great value. The same author has published *Annulosa Javanica,* part 1st, 4to, Lond. 1825, and has contributed various papers to the *Linn. Trans.,* the *Zoological Journal,* and the *Transactions* of the Zoological Society.

The Rev. Landsdown Guilding, of St Vincent's, deceased, was one of the most active of the naturalists ever stationed within the tropics. He was the author of several entomological papers published in the *Transactions of the Linnæan Society* (1829, &c.), and the *Zoological Journal.*

John James Hagenbach, who died in 1826, was one of the conservators of the Royal Museum of Leyden. He made known a singular coleopterous insect, from Java, in his *Mormolyce novum genus.* 1 vol. 8vo, with a plate, Nuremberg, 1825. He was also the author of *Symbola Faunæ Insectorum Helvetiæ.* Fascic. 1, with plates, Basil, 1822.

Aroid David Hammel wrote *Quelques Observations sur la Blatte Germanique,* in 8vo, Petersburg, 1821; and between that year and 1827 he published six numbers of *Essais Entomologiques.*

Lepelletier de St Fargeau is known as the author of a *Monographie des Chrysis des environs de Paris,* in the *Ann. du Mus. d'Hist. Nat.* No. 58, and of a *Monographia Tenthredinetarum Synonymia extricata,* 1 vol. 8vo, Paris, 1823. He has communicated to the Academy of Sciences *Observations sur les accouplements de diverses espèces de Volucelles, genre de Diptères;* and has composed, jointly with M. de Serville, the tenth volume of *Entomologie de l'Encyclopédie Méthodique.* With M. Brullé, he has published a *Monographie du Genre Crabro in Ann. Soc. Ent.* iii., 683; and in his own proper person is the author of *Hist. Nat. des Insectes Hyménoptères.* 3 vols. 8vo. fig. Paris, 1836.

C. R. G. Wiedmann, professor at Kiel, has written *Diptera exotica,* 1 vol. in 8vo, part first, with figures, Kiel, 1821. He is likewise the author of *Analecta Entomologica,* in 4to, with plates, Kiel, 1824, and of other works.

C. L. Sahlberg, professor of natural history at Abo in Finland, commenced an Entomology of that country, under the title of *Dissertatio Entomologica Insecta Fennica enumerans.* 8vo, 1817–1823. He is also the author of *Periculi Entomographici.* 1 vol. 8vo, with plates, Abo, 1823.

George Dahl, of Vienna, an entomological merchant, or dealer in insects, and a well-instructed entomologist, has printed catalogues of the different orders, particularly *Coleoptera und Lepidoptera.* 1 vol. 8vo, Vienna, 1823.

M. Charpentier is favourably known as the author of *Horæ Entomologicæ adjectis tabulis novem coloratis.* 4to, 1825. *Libellulinæ Europeæ, descript. et depict. Lipsiæ,* 1840. *Orthoptera, descript. et depict.* Lips., 1841–45.

John William Dalman, formerly director of the Stockholm museum, is known as the author of the following works:—*Insectorum Nova Genera.* 8vo, Holmiæ, 1819. —*Analecta Entomologica,* with plates, 1 vol. 4to, Holmiæ, 1823.—*Prodromus Monographiæ Castniæ,* with a plate, 1 vol. 4to, 1825.—*Om nagra svenska arter of Coccus,* with plates, 4to, Stockholm, 1826.—A monograph on the *Chalcidites,* or *Pteromalini* of the author. 1 vol. 8vo, 1820. —*A Synoptical Table of the Butterflies of Sweden,* published in the *Memoires de l'Academie de Stockholm.* 1816.—*Ephe-*

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merides Entomologicæ. 1 vol. 8vo, Holmiæ, 1824.—A memoir on certain *Ichneumonides.* 1 vol. 8vo, 1826.—Also of a memoir in the Swedish language, on the *Insects inclosed in Amber.* 1 vol. 8vo, 1826.

Gotthelf Fischer de Waldheim, a German naturalist, is (or was) director of the Imperial Museum of Moscow. To this author we owe innumerable papers, entomological and other, in the Memoirs and Bulletins of the Société Impér. de Moscou, &c. We shall here name only some of such as have been published apart. *Entomographia Imperii Russici (et genera Insectorum systematice exposita, &c.)* 4 vols. 4to, col. pl., Mosquæ, 1820–43.—*Lettre au Dr Panzer, contenant un notice sur plusieurs nouveaux Insectes.* 4to, Ibid. 1820.—*Notice sur l'Argus de Perse (Mallèh de Mianèh), décrits par les voyageurs sous le nom de Punaise vénimeuse de Miana.* 4to, Ibid. 1823.—*Lettre sur le Physodactyle, nouveau genre de Coléopteres Elateroides.* 8vo, Ibid. 1824.—*Notice sur le Tettigopsis, nouv. gen. d'Orthoptères de la Russie.* 8vo, Ibid. 1830.—*Notice sur Phlocerus, nouv. gen. d'Orthop. de la Russie.* 4to, Ibid. 1833.—*Catalogus Coleopterorum in Siberia orientali, &c.* 8vo, Mosc. 1842.

J. E. Fischer von Roeslerstamm. *Ueber das Tödten und Aufweichen der Schmetterlinge.* Prag. 1827.—*Abbildungen zur Berichtigung und Ergänzung der Schmetterlingskunde besonders der Mikrolepidopterologie als Suppl. zu Treitschke's u. Hübner's Europ. Schmetterlingen.* 4to, fig. Leipz. 134, *et seq.*

T. Babt. Fischer. *Tentamen Conspectus Cantharidiorum.* 4to, Monach. 1827.

Leop. Henr. Fischer. *Dissert. inaug. zool. sistens enumerationem Coleopterorum circa Friburgum Brisg. &c.* 8vo, 1843.

A. M. G. Dumeril. Of the numerous writings of this distinguished naturalist, we shall now name those on entomology alone. *Exposition d'une methode Naturelle pour l'étude et la classification des Insectes.* 8vo, fig. Paris, 1801. —*Considérations générales sur la classe des Insectes.* 8vo, fig. Paris, 1823. He has published many excellent *Rapports* in the *Comptes Rendus.*

Leon Dufour, a physician in Saint Sever (Landes), is the author of several highly esteemed contributions to entomology. We shall here mention *Mémoire Anatomique sur une nouvelle espèce d'Insecte du genre Brachine,* in the 18th vol. of the *Annales du Museum d'Hist. Nat.* Paris, 1811. —*Memoires sur l'Anatomie des Coléoptères, des Cignles, des Cicadelles, des Labidoures* or *Forficulæ;—sur une nouvelle espèce* d'*Ornithomyia;—sur le genre Ocyptère;*—all printed in the *Annales des Sciences Naturelles.* 1824-28. He has also written *Sur l'Anatomie des Scolies,* in the *Journal de Physique.* Sept. 1818; besides describing many new species of *Coleoptera,* and the anatomy of *Ranatra linearis,* and of *Nepa cinerea,* in the *Annales Génerales des Sciences Physiques.* Among his other works may be mentioned, *Recherches Anatomiques et Physiologiques sur les Hémiptères, accompagnées de considerations relatives à l'histoire naturelle et à la classification de ces insectes.* 1 vol. 4to, with plates, Paris, 1833.—*Recherches anatomiques, &c., sur les insectes Coleoptères des genres Macronychus et Elmis.* 8vo, Paris, 1835.—*Mémoire pour servir à l'histoire des Odynères, &c.* 8vo, Ibid. 1839.—*Hist. des metam. des Cecidomyes.* 8vo, Ibid. 1840.—*Observations sur les metam. du Cerceris bupresticida, &c.* 8vo, Ibid. 1840.—*Recherches anatomiques et physiologiques sur les Orthoptères, les Hymenoptères, et les Neuroptères.* 4to, Ibid. 1841.

A. J. Duponchel is the continuator of the *Histoire Naturelle des Lepidoptères de France,* of the late M. Godart, 11 vols. 8vo, Paris, 1821-40. There is a *Supplement* to the preceding, in 4 vols. 8vo, Ibid. 1834-45. He has published a *Monographie du genre Erotyle,* with plates, in the 12th vol. of the *Mémoires du Museum;* and is, moreover, the author of the following works: *Iconographie des Chenilles pour faire suite à l'Hist. Nat. des Lepidoptères de France.* 31 *livrais,* pl. col. 8vo, Paris, 1832-42.—*Tableau methodiques des Lepidoptères de l'Europe, distribués en familles, &c., pour servir de complement et de rectification à l'Hist. Nat. des Lepidoptères de France.* 8vo, Paris, 1844. M. Duponchel has contributed largely to the *Ann. de la Soc. Ent.,* and other periodicals.

Robineau-Desvoidy, a physician of St Saveur, has written several elaborate treatises relating to Entomology, such as *Recherches sur l'organisation vertebrale des Crustacés, des Arachnides, et des Insectes.* 1 vol. 8vo, Paris, 1828.—*Essai sur la tribu des Culicides,* in the 2d vol. of *Mém. de la Soc. d'Hist. Nat.* de Paris; and a work *Sur les Diptères de la tribu des Muscides,* printed in the *Mém. des Savants Etrangers de l'Acad. des Sciences.*

John Curtis, F.L.S., &c., an English entomologist, commenced and concluded several years ago a work entitled *Illustrations of the Genera of British Insects.* "Leurs charactères," says Baron Cuvier, "y sont représentés avec la plus grande fidélité." It may be safely asserted, that for elegance of design and accuracy of execution, combined with the most beautiful and exquisitely finished mode of colouring, it is a matter of doubt whether any rival to its plates can be found within the entire range of entomological productions. A new and less costly edition has recently appeared. Mr Curtis has also published a *Guide to an arrangement of British Insects.* 8vo, 1831.

James Francis Stephens, F.L. & Z.S., published a *Systematic Catalogue of British Insects,* in one large volume 8vo, 1829. Although it presents merely a list of names and synonyms, this is a most praiseworthy and valuable work, and was the first to exhibit a systematic view of our indigenous species. It enumerates 10,012 names of native insects, a number greatly surpassing what could have been anticipated a few years back. Mr Stephens is likewise the author of a well-known work, *Illustrations of British Entomology,* in 10 vols. 8vo, London, 1827–35. It is pleasingly adorned in a pictorial point of view, and, containing very excellent descriptions, has not failed in being classed by competent judges with the most successful efforts in its line. By the same writer we have also the *Nomenclature of British Insects,* 2d edit. 1833,—a useful compendium.

H. J. Stainton has published several papers relating to insects in the *Trans. Entom. Society.* By the same author we have also the three following works:—*Nomenclature of British Insects.* 2d ed. 1833.—*An Abstract of the Indigenous Lepidoptera, contained in the "Verzeichniss bekannter Schmetterlinge" of Hübner.* London, 1835.—*A Manual of British Coleoptera,* or *Beetles, containing a brief Description of all the species of Beetles hitherto ascertained to inhabit Great Britain and Ireland.* 8vo, Lond. 1839.

William Swainson, F.R.S., &c., a noted naturalist, and excellent draftsman, has published, in his *Zoological Illustrations* (first series, 3 vols. 8vo, 1820-3, second series, 3 vols. 8vo, 1832-8), many beautiful figures of new and rare insects, chiefly Lepidoptera. The careful study of Mr Swainson's Illustrations, as well as of those of Mr Curtis, must prove delightful, not alone to the mere entomologist, but to every eye accustomed to receive pleasure from the tasteful representation of nature. The figures of our present author are almost all drawn by himself on stone. His more recent entomological work is, *On the History and Natural Arrangement of Insects* (in conjunction with Mr Shuckard). 8vo, Lond. 1840.

W. Wood, F.L.S., is author of *Illustrations of the Linnæan Genera of Insects,* 2 vols. 12mo, London, 1821; and of *Index Entomologicus, or a complete illustrated Catalogue of the Lepidopterous Insects of Great Britain,* 8vo, Lond. 1839-45. This useful and meritorious work contains 1944

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coloured figures of butterflies and moths. A supplement by Mr Westwood has since appeared, containing the recently discovered species.

THOMAS HORSFIELD, M.D., an English naturalist now or formerly in the service of the Honourable East India Company, is the author of *Catalogue of Lepidopterous Insects* in the museum of that Company, parts i. and ii. royal 4to, London, 1828-29,—a work of great interest, from its excellent representation of the *metamorphoses* of many Javanese butterflies.

FRANCIS GEBLER, a Russian physician and naturalist, stationed at Barnaoul in Siberia, has published a memoir in 4to, entitled *Observationes Entomologicæ*, besides various papers in the *Mémoires de la Soc. des Naturalistes de Moscou*, chiefly vols. v. vi. and viii.; also, *Catalogus Coleopterorum Siberiæ Occidentalis, &c.* 8vo, Berlin, 1830.—*Notæ et additamenta ad hunc Catalogum.* 8vo, Mosc. 1833. He has done much to illustrate the insects of Siberia, of which otherwise we know but little.

ERNEST FREDERICK GERMAR, a German naturalist, professor of mineralogy at Halle, is the author of *Dissertatio sistens Bombycum Species, &c.* 4to, Leipzig, 1811. Conjoined with Zinken Von Zommer, he continued Illiger's *Magazin für Insektenkunde*, under the title of *Magazin der Entomologie*, 4 vols. 8vo, Hallæ, 1813-21; and with Kaulfuss, carried on Ahren's *Fauna Insectorum Europæ.* Fascic. iii.-viii., 8vo, Ibid. 1816-22. In his *Reise nach Dalmatien* (8vo, Altenb. 1817), he gives an account of the insects he encountered. He is the author of *Insectorum Species Novæ aut minùs cognitæ, &c.* 1 vol. 8vo, fig., Halle, 1824. Professor Germar has particularly applied himself to the *Curculionidæ*; and in the work last named, in which he describes 891 Coleopterous species, 318 belong to that splendid family. He has written a great many separate papers in the *Mag. der Ent.*, Silbermann's *Rev. Ent.*, and in a work conducted by himself, the *Zeitschrift für die Entomologie*, 5 vols. 8vo, Leipz. 1839-44.

JEAN BABTISTE GODART compiled the article *Papillons* of the *Encyclopédie Méthodique*, and wrote the first five volumes of the *Histoire Naturelle des Lépidoptères ou Papillons de France*, commenced in 1821, and continued (Godart being dead) by M. Duponchel. It now consists of 11 vols. (in 13) 8vo, Paris, 1821-40. The *Supplements* form 4 more vols. Ibid. 1832-45. We likewise owe to M. Godart (in conjunction with MM. Duponchel and Guenée) *Iconographie des Chenilles pour faire suite à l'Hist. Nat. des Lépidoptères, &c.*, in livraisons, 8vo, Paris, 1832-42.

FRANCIS BONELLI, director of the cabinet of natural history, and professor of zoology, at Turin (now deceased), was the author, among other works, of *Observations Entomologiques*, in two parts, published in the *Mémoires de l'Academie des Sciences de Turin*, for 1809. Their object is the genus *Carabus* of Linnæus, which he has greatly divided; and most of his new genera have been received and adopted by entomologists. In the thirtieth volume of the above-named memoirs, Professor Bonelli has also published *Descrizione de sei nuovi insetti lepidopteri della Sardegna*, 4to, Torino, 1824.

CHARLES GUSTAVUS CARUS, professor at Dresden, is the author (we need not here mention his well-known works on physiology and comparative anatomy) of a *Memoir on the Circulation of the Larvæ of Neuropterous Insects.* 4to, Leipsic, 1827.

J. CHABRIER has composed a series of memoirs on the flight of insects, in which the muscular economy is well described. They are now published in a collected form, with the title of *Essai sur le Vol des Insectes*, 1 vol. 4to, Paris, 1820.

C. G. MANNERHEIM, a councillor of the Emperor of Russia, has contributed to Entomology:—*Eucnemis insectorum genus*, 1 vol. 8vo, with plates, 1823:—*Observations sur le genre Megalope*, in the tenth volume of the Memoirs of the Imperial Academy of Sciences of St Petersburg, 1824:—*Description de quarante nouvelles espèces de Scarabæides du Brazil*, in 4to, with plates, 1829. M. Mannerheim is likewise the author of *Précis d'un nouvel arrangement de la famille des Brachélytres*, in 4to, Petersburg, 1830; and has contributed to the *Bulletin des Nat. de Mosc.* and the *Rev. Zool.*

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STRAUS-DURCKHEIM is the author of a very admirable work,—*Considerations générales sur l'Anatomie comparée des animaux articulés, auxquelles on joint l'anatomie descriptive du Hanneton.* 1 vol. 4to, with plates, Paris, 1828.

FREDERICK TREITSCHKE, a writer of authority on the Lepidopterous order, has continued Ochsenheimer's *Schmetterlinge von Europa*, 10 vols. 8vo, Leipz., 1807-35; and is the author of *Hulfsbuch für Schmetterlings sammler.* 8vo, fig., col., Wien. 1834.

J. GUST. BILLBERG. *Monographia Mylabridum.* 8vo, Holmiæ, 1812.—*Enumeratio Insectorum in museo suo.* 4to, Ibid., 1820.—*Synopsis Faunæ Scandinaviæ.* 12mo, Stockholm, 1827.

ETIENNE GEOFFROY SAINT-HILAIRE. *Memoires sur l'organisation des Insectes.* 4 parts, 8vo, Paris, 1820. The writings of this great anatomist are innumerable on other departments of natural history.

FR. ESCHSCHOLTZ. *Entomographien.* 8vo, fig. Berl. 1822.—*Species Insectorum novæ descriptæ.* Mosquæ, 1823. More recently we are indebted to this author for many excellent contributions to the *Mem. Soc. Nat. Moscou, &c.*

J. A. ARNBERG. *Diss. Entom. de Hemipteris maxillosis capensibus.* 4to, Upsal, 1822.

BARON F. DE LAFRESNAYE. *Reflexions sur les Localités propres à certain espèces d'Insectes.* 8vo, Paris, 1823.

J. K. BROCH. *Correspondance Entomologique.* 8vo, Mulhausen, 1823.

J. KOCHLIN. *Correspondance Entomologique.* 8vo, fig. Mulh., 1823.

C. U. WERTERLING. *Dissert. Entomol. de Hemipteris rostratis capensis.* 4to. Upsal, 1822.

B. F. FRIES. *Observationes Entomologicæ.—Monographia Simuliarum Sueciæ.* 8vo, fig. Stockh., 1824.—*Monographia Tanyporum Sueciæ.* 8vo, fig., Lund., 1823.

—— JERM. *The Butterfly Collector's Vademecum.* 12mo, Ipswich, 1824.

B. JAGER. *Catalogus Insectorum, quæ in Chersonesum Tauricum collegit.* 8vo, fig., St Petersb., 1827.

J. VANDER-HŒVEN. *Systematische Beschrijving van eenige Insecten van Noord-Nederland.* 8vo, Amsterdam 1827.

A. INGPEN. *Instructions for collecting, rearing, and preserving British Insects.* 18mo, fig., col., Lond. 1827.

CH. LIER and F. DUVAL. *Collection des Lépidoptères ou Papillons des Pays-Bas et de France.* 8vo, fig., Brux. 1827.

BERN. ANGELINI. *Ascalafi Italiani, con nuova Specie.* 8vo, Milano, 1827.

M. SONOGLA has contributed to entomology a work under the title of,—*Insectorum Liguriæ Species novæ.* 2 vols. 4to. Genuæ, 1827.

F. L. LEBREUX. *Hist. Nat. des Lépidoptères, ou Papillon.* 12mo, Valencien. 1827.

AL. LEFEBURE. *Description de divers Insectes inédits recueillis en Sicile.* 8vo, fig., Paris, 1837. This author has also contributed to the *Ann. de la Soc. Ent. de France.*

GIUS. BERTOLONI. *Lettera a Conte Fil. Re Su Varii Insetti nocivi all'Agricoltura.* 8vo, Milano, 1812.—*Memoria sopra due rare Farfalle trovate nel Territorio Lunese.* 8vo, fig., Bol. 1829.—*Descriptio novæ speciei e Coleopterorum ordine.* 4to, fig., Bonon. 1837.—*Diss. de Insectis quæ hieme et vere ann 1832-33 sata Tritici vastarunt in*

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arvis Italiæ. 4to, fig., Bonon. 1837.—*Fauna Insettologica del territorio Bolognese.*

THEOD. THON has published some representations of exotic Coleoptera, under the title of *Abbildungen ausländischer Insecten.* I. Käfer, 4to, Jena, 1826-28.—Also *Neue Schmetterlingsbelustigungen.* Prospectus, 8vo, Jena, 1828.

O. G. COSTA. *Osservazione sugli Insetti dell' Olivo e delle Olive.* Atti di Napoli, 1828.—*Specie Nuove di Lepidoptèri del Regno di Napoli.* 8vo, fig., Nap. 1832.—*Nuove Osservazione intorno alle Cocciniglie ed ai loro pretési maschi.* 4to, fig., Napoli, 1835.—*Memoria degli Insetti di terra Otranto.* Atti Accad. Nap. iv.—*Descrizione degli Insetti che vivono ne fumajuoli del cratere del Vesuvio.* 4to., Ibid., 1836.

FR. FROLICH. *Enumeratio Tortricum,* &c. 8vo, Tubing. 1828.

—— BERLÈZE. *Destruction de la larve du Hanneton.* 8vo, Paris, 1828.

LEON LALANDE. *Manuel Entomologique pour la Classification des Lépidoptères de France, &c.* 2 vols. 8vo, fig. Paris, 1829.

FRANCIS ETIENNE GUERIN-MENEVILLE. This assiduous author and excellent draftsman has contributed largely to entomological science, especially in the way of illustrated works. A great majority of his scientific papers have appeared in the *Mag. de Zoologie,* and the *Rev. Zoologique,* of which periodicals he has had the direction. His *Iconographie du Règne Animal* of Cuvier illustrates the class *Insecta* (of which there are 111 plates), in common with all the other great groups, and consists of 7 vols. 8vo, Paris, 1829-39. He has published a *Magazine d'Entomologie, ou Description et Figures des Insectes inédits ou non encore figurées,* 8vo, Paris, 1830; and, jointly with M. Percheron, *Genera des Insectes, ou Exposition detaillée de tous les caractères propres à chacun des genres de cette classe d'animaux.* 8vo, fig. col., Paris, 1831-35. He worked the entomological portion of Duperrey's *Voyage autour du Monde* (fol., Paris, 1829), of Belanger's *Voyage aux Indes Orientales* (4to, Paris, 1831-44), of Bory de St Vincent's *Expedition Scientifique en Morée* (4to, Paris, 1832-5), and of Delessert's *Souvenirs d'un Voyage dans l'Inde* (8vo, Paris, 1843). Along with M. Goudot he has given us an account of *Insectes nouveaux observés sur les plateaux des Cordillères et dans les Vallées Chaudes de la Nouvelle Grenade;* and (with Reiche) has described some Abyssinian insects in the *Voyages* of Ferret and Galinier—of Vaillant and Lefebure. Of these later essays we do not know the date. M. GUERIN's latest work, to our knowledge, is his *Recherches sur les vers à soie sauvages et domestiques.* 8vo, Paris, 1854.

JEAN MACQUART. This author excels in his knowledge of the Dipterous order. *Insectes Diptères du Nord de France.* 5 vols. 8vo, fig., 1825-29.—*Hist. Nat. des Insectes Diptères; ouvrage faisant suite à Buffon.* 2 vols. 8vo, fig., Paris, 1834-35.—*Diptères Exotiques nouveaux, ou peu connues.* 3 vols. 8vo, fig., Paris, 1836-40.—*Memoire sur les harmonies entomologiques, lu en séance générale du Congrès Scientifique de France.* 8vo, Arras.—*Memoires sur les Insectes Nuisibles à l'Agriculture* Ibid. (Zuchold's *Bibliotheca,* 1854.)

JOHN WILLIAM ZETTERSTEDT, a Swedish naturalist, has published several works on the entomology of northern Europe. *Orthoptera Suecica disposita et descripta.* 8vo, Lundæ, 1821.—*Fauna Insectorum Lapponica.* 8vo, Hamm, 1828.—*Insecta Lapponica.* 4to, Leipz., 1838-40.—*Diptera Scandinaviæ disposita et descripta.* 9 vols. 8vo, Lundæ, 1842-50.

JEAN VICTOR AUDOUIN (now deceased), sub-librarian to the Institute of France, and professor in the Jardin des Plantes, is the author of several signal works.—*Recherches Anatomiques sur les thorax des animaux articulés, et celui des Hexapodes en particuliers.* 8vo, Paris, 1821.—*Rech. Anat. sur le Drile jaunâtre.* 8vo, Ibid., 1824. Conjointly with M. Milne-Edwards, M. Audouin is author of *Iconographie des Insectes,* 32mo, Paris, 1828; and of *Resumé d'Entomologie.* 2 vols. 8vo, Ibid., 1829.—With M. Brulé he has published *Hist. Nat. des Insectes, traitant de leur Organisation, de leurs Mœurs en général,* &c. 4 vols. 8vo, fig. col., Paris, 1834-36;—and *Description des Espèces nouvelles ou peu connues de la famille des Cicindélètes, faisant partie de la Coll. du Muséum.* 4to, fig. col., 1839. Many years ago he gave an *Explication Sommaire* of the entomological plates of the great French work on Egypt. His latest and most remarkable work is his *Histoire des Insectes nuisibles à la vigne et particulièrement de la Cote d'Or,* &c. (6 livrais.) 4to, pl. col., Paris, 1840-42. This production almost equals in minute and laborious accuracy the famous anatomical volume by Lyonnet on the Chenille de Saule.

H. MILNE-EDWARDS. Of this distinguished writer on comparative anatomy and physiology, the only work with which we are acquainted relating specially to insects is the *Resumé d'Entomologie,* just mentioned as a joint-production with M. Audouin. 2 vols. 8vo, Paris, 1828-29.

J. A. BOISDUVAL. This noted entomologist was formerly conservator of the collection of Comte Dejean, and has published numerous works on insects, all of great value.—*Notice sur cinque espèces nouvelles de Lépidoptères d'Europe.* 8vo, fig., Paris, 1827.—*Monographie des Zygænides suivie d'un Tableau méthodique de classification des Coléoptères.* 8vo, Ibid., 1828.—*Europæorum Lepidopterorum Index Methodicus.* 8vo, Ibid., 1829.—*Partie Entomologique de la Rélation du Voyage autour du Monde en* 1826-29, *par* M. Dumont d'Urville, 5 livraisons, fol., Paris.—*Faune Entomologique de Madagascar, Bourbon, et Maurice; partie des Lépidoptères, avec des notes sur leurs mœurs* par Sganzin. 8vo, fig., Paris, 1833.—*Faune Entomologique de l'Océanie, contenant la description de toutes les espèces de Coléoptères, &c., découvertes jusqu'à ce jour dans cette partie du monde, et les espèces des autres ordres rapportées par l'Expedition de l'Astrolabe.* 2 vols. 8vo, atlas, Paris, 1832-35. In this work the author has given a descriptive catalogue of the insects of Australia, and the islands of the Pacific, so far as they had been then ascertained, or his opportunities extended.—*L'Entomologie du Voyage autour du Monde sur la Corvette la Coquille.* 2 vols. 8vo, pl. col. in folio, Paris, 1835.—*Spécies général des Lépidoptères.* 8vo, Paris, 1836.—*Icones historiques des Lépidoptères d'Europe nouveaux ou peu connus.* 8vo, Paris, 1832-41 (par livraisons).—*Hist. Nat. des Insectes Lépidoptères.* 8vo, Paris (in Suites à Buffon).—*Genera et Index Methodicus Europæorum Lepidopterorum.* 8vo, Paris, 1840. In conjunction with M. Lacordaire, our author has published, *Faune Entomologique des environs de Paris,* &c., *Coléoptères.* 1 vol. 18mo, Paris, 1835;—with Dejean and Aubé, *Iconographie et Hist. Nat. des Coléoptères d'Europe.* 12 vols. 8vo, pl. col., Paris, 1829-40;—with Leconte, *Hist. gen. et iconographie des Lépidoptères et des Chenilles de l'Amérique Septentrionale.* Par livraisons. 8vo. Paris, 1830-42;—with Rambhur and Graslin, *Collection iconographique et historique des Chenilles d'Europe,* &c. Par livraisons, 8vo. Paris, 1832-37.—M. Boisduval has recently contributed to our knowledge of the Lepidoptera of California in the *Ann. de la Soc. Ent.* of France.

GEORGE SAMOUELLE is the author of *Nomenclature of British Entomology, alphabetically arranged.* 8vo, London, 1819.—*The Entomologist's useful Compendium,* &c. 8vo, with figures. Lond., 1819.—*General directions for collecting and preserving Exotic Insects,* &c. 8vo. Lond. 1826.—*The Entomological Cabinet.* 2 vols. 8vo, Lond. 1834.

L. ARRAGONA. *De quibusdam Insectis novis aut rarioribus.* 8vo, Tic. Reg. 1830.—*De quibusdam Coleopteris Italiæ Tentamen.* 8vo, Tic. Reg. 1830.

James Rennie. *Insect Architecture, to which are added, Miscellanies on the Ravages, the Preservation for purposes of Study, and the Classification of Insects.* 2 vols. 8vo. Lond. 1830. New Edition in Knight's Weekly Volume (vols. 39 and 40), Ibid., 1845.—*Alphabet of Insects, for the use of Beginners.* 12mo, Lond. 1832.

Chr. Zimmermann. *Monographie der Carabiden.* 8vo, Berl. u. Halle, 1831–32.

F. S. Hemprich (and C. G. Ehrenberg).—*Symbolæ physicæ, seu icon. et des. Insectorum quæ in itinere, &c.* Folio, Berol. 1830–34.

—— Franck. *Catalogue des Lépidoptères de sa Collection.* 8vo, Strasb. 1830.

Aloys Cadolini. *Enumeratio Carabicorum Ticinensium,* &c. 8vo, Ticini Reg. 1830.

—— Brambilla. *Enumeratio Caraborum Ticinensium.* 1830.

P. W. Brandsten. *Bombi Scandinaviæ, monographia tractati et Iconibus illustrati.* Lond. Goth. 1832.

Maximilian Spinola, a Genoese of noble birth, and an accomplished naturalist, is the author of the following works:—*Insectorum Liguriæ species novæ aut rariores.* 2 vols. 4to, fig., Genuæ, 1806–8.—*Essai sur les Genres d'Insectes appartenant à l'ordre des Hemiptères,* &c. 8vo, Genes. 1837, Paris, 1840.—*Essai sur la Fulgorelles.* 2 vols. 8vo, fig., Genes, 1839.—*Description d'un nouveau genre de Coléoptères Xylophages, et de quelques autres Insectes.* 8vo, fig. Paris, 1839.—*Considerazioni sopra i costumi degli Insetti Imenotteri del genere Sirex,* Fab., *e sopra il miglior porto dei Sireciti nel methodo razionale.* 8vo, Genova, 1843.—*Osservazioni sopra i caratteri naturali di tre famiglie d'Insetti imenotteri, le Vesparie, le Massaride, e le Crisidide.* 8vo, Geneva, 1843.—*Essai Monographique sur les Clerites, insectes Coléoptères.* 2 vols. 8vo, pl., col., Genes, 1844.—*Tavola sinottica dei generi spettanti alla classe degli Insetti Artroidignati, Hemiptera, Linn.* 4to, Modena, 1850. Signor Spinola has moreover contributed numerous entomological memoirs, of a more special nature, to the *Ann. du Mus.*, the *Ann de Soc. Ent.*, the *Revue Zoologique,* and other periodicals.

T. E. Kernell. *Exercitationes hymenopterologicæ ad illust. faunam Suecicam.* 8vo, Lond. Goth. 1831.

F. C. Kielsenn. *Icones Insectorum.* 8vo, Hafn. 1835.

R. A. Philippi, in the form of an inaugural dissertation, has given us *Orthoptera Berolinensis.* 4to, fig., Berol., 1830.

Max. Perty. *Delectus animalium articulatorum quæ in Itinere per Braziliam collegerunt Dr de Spix et Dr de Martius.* Fol. fig. fasc. i.–iii., Monach, 1830-33.—*Observationes nonnullæ in Coleoptera Indiæ Orientales.* 4to, Monach, 1831.—*De Insectorum in America Meridionale habitantium vita genere moribus ac distributione geographicâ Observationes nonnullæ.* Fol., Ibid. 1833.

T. Bruand. *Entomologie.* 8vo, Besançon, 1844.

Aug. Brullé. *Coup-d'œil sur l'Entomologie de la Morée.* 8vo, Paris, 1831.—*Hist. Nat. des Insectes. Coléoptères.* Paris, 1834.—*Thése sur le Gisemont des Inseetes fossiles, &c.* 4to, Paris, 1839.—Also various papers in the *Ann. de la Soc. Ent. de France,* and (with Guérin-Méneville) the entomological portion of the French *Expedition Scientifique en Morée,* 4to, atlas fol. To M. Brullé we are more recently indebted for a work on the *Ichneumons,* forming the fourth volume of the *Suites à Buffon.*

Giuseppe Gené. Author of various contributions to entomology in the Memoirs of the Academy of Turin, and other foreign works. He has published apart, *Su gli Insetti più nocivi.* 8vo, con. tav., Milano, 1827.—*Saggio di una Monographia delle Forficulé indigene.* 4to, Padua, 1832.—*De quibusdam Insectis Sardiniæ novis aut minus cognitis.* Fasc. i. ii., 4to, Taurini, 1837-8.—*Memoria per servire alla Storia Naturale di alcuni Imenotteri.* 4to, Modena, 1842.—*Saggio su gli Insetti più dannosi all' Agricoltura, agli animali domestici, ed ai prodotte dell' Economia rurale.* 8vo, Milano, 1827, 2d edit. 1836.—*Istruzione su gli Insetti più dannosi all' Agricoltura in Piemonte, e su i mezzi più facili di distruggioli.* 8vo, Torino, 1840.

F. Villiers, and Guenée. *Tableaux synoptiques des Lépidoptères d'Europe, contenant la description, &c.* 4to, fig., Paris, 1834.

A. Guenee. *Microlepidopterorum Europæorum Index Methodicus.* 8vo, Paris, 1846. To this author we also owe three volumes published in the *Suites à Buffon,* describing the various species of *Noctuæ,* and a fourth containing the *Pyralidæ.* He is now engaged on the *Geometridæ* and *Bombycidæ.*

J. W. Helfer. *Terminologia Entomologica.* 8vo, Ticini Rez. 1832.

Fr. J. Pictet of Geneva, is the author of many excellent and elaborate works. *Memoire sur les Larves des Némoures.* 8vo, fig., Paris, 1832.—*Recherches pour servir à l'Histoire et à l'Anatomie des Phryganides.* 4to, fig., Geneve, 1834.—*Note sur les Organes respiratoires des Capricornes.* 4to, fig., Ibid. 1836.—*Description de quelques nouvelles espèces de Néuroptères du Musée des Geneve.* 4to, fig., Ibid. 1836.—*Histoire Naturelle, generale et particulière des Insectes Néuroptères:* I. Famille de *Perlidés.* 8vo, fig., Ibid. 1841.

J. P. Rambur. *Catalogue des Lépidoptères de l'Isle de Corse, avec la description et la figure des espèces inédites.* 8vo, fig., Paris, 1832.—*Faune Entomologique de l'Andalousie.* 2 vols. 8vo, fig., Ibid. 1837.—A more recent volume on *Neuroptères,* in the *Suites à Buffon.*

Vinc. Kollar. *Monographia Chlamydum.* Folio, fig. col., Vien. 1824.—*Brasiliens Vorzüglich lastige Insecten.* 4to, fig., Wien. 1832.—*A Treatise on Insects injurious to Gardeners, Foresters, and Farmers.* 8vo, fig. Lond. 1840.

A. Gust. Dahlbom. *Monographia Chrysidum Sueciæ.* 8vo, Lund. 1829.—*Monographia Pompilorum Sueciæ.* 8vo, Lond., Goth. 1829.—*Bombi Scandinaviæ Monographice tractati et icon. illustrati.* 8vo, fig. col., Lond. Goth. 1832.—*Prodromus. Hymenopterologiæ Scandinaviæ.* 8vo. Lond., 1833–36.—*Clavis novi Hymenopterorum Systematis,* &c. Ibid. 1835.—*Conspectus Tenthredinidum,* &c. 4to, Hafniæ, 1835.—*Examen historico naturale de Crabronibus Scandinavicis,* &c. Lund. 1838.—*Synopsis Hymenopterologiæ Scandinavicæ.* 4to. Lond. 1839–40.—*Dispositio methodica speciorum Scandinavicarum pertinentium ad familias Sphegidarum, Pompilidarum, Larridarum,* &c. Ibid. 1842.—*Hymenoptera Europæa precipue borealia,* &c. Lund. 1843–45.

Charles Nodier, a literary writer and tourist in Scotland, has given us *Bibliographie Entomologique, ou Catalogue raisonné des Ouvrages relatifs à l'Entomologie et aux Insects, avec de Notes critiques et l'Exposition des Methodes.* 12mo, Paris, 1801.—*Examen critique des Lettres à Julie sur l'Entomologie, par E. Mulsant.* 8vo, Paris et Lyons, 1833.

Thomas Say has added greatly to our knowledge of the insects of the Western World by numerous contributions to the American journals. These have been partially collected by a French author, under the title of *Œuvres Entomologiques contenant tous les Memoires que M. Say a publiés dans les Journaux Scientifiques des Etats-Unis sur l'Entomologie e l'Amérique du Nord,* rec. et trad. par Gory. 8vo, Paris, 1837. Mr Say is also the author of *American Entomology, or Descriptions of Insects of North America.* 3 vols. 8vo, Philadelphia, 1824–28.—*Explanation of terms used in Entomology.* Philad. 1825.—*Descriptions of new species of Heteropterous Hemiptera of North America.* 8vo, New Harmony, 1831.—*Curculionites of North America, with Observations on some of the species already known.* 8vo, Indiana, 1831.—*Descriptions of new species of North American Insects,* &c. 4to, 1833–36.

Biblio-graphy.

M. Solier is the author of various papers, chiefly on the Coleopterous tribes, in the *Annals of the Entomological Society of France.* 1835, et seq.

C. W. Hahn. *Icones ad Monographiam Cimicum.* 12mo, Nurnb., 1826.—*Die Wanzenartigen Insecten.* 8vo, Nurnb., 1813-35.—*Icones Orthopterorum.* 4to, Nurnb., 1836.

A. H. Haliday. *Hymenoptera Britannica. Oxycera et Alysia.* 2 vols. 8vo, Lond., 1839.—Many contributions to the *Entomological Magazine*, &c.

—— Bertolotti. *The History of the Flea, with Notes and Observations.* 2d ed., 8vo, fig., Lond., 1834.

A. Villa has published a catalogue of the duplicates of his own collection—a work of a useful kind in facilitating exchanges. *Coleoptera Europæ dupleta in collectione* Villæ. 8vo, Mediolani, 1833.—*Alterum supplementum Coleopterorum Europæ, sive additio ad catalogum, et supplementum* I. *dupletorum collectionis* Villæ, &c. 8vo, Mediol., 1838.—*Note su alcuni Insetti osservati nel periodo dell' ecclisse del* 8 *Luglio*, 1842. 12mo, Milano, 1842.

W. J. Little. This assiduous collector has added greatly to our knowledge of the localities of Scottish *Coleoptera*, although we have no separate work by himself upon the subject.

Ant. Longhi. *Abitazione dei Coleotteri e dei mezzi acconci di farne caccia.* 8vo, Milano, 1834.

H. Lucas. *Hist. Nat. des Lépidoptères d'Europe.* 8vo, Paris, 1835.—*Hist. Nat. des Lépidoptères étrangers.* 8vo, fig. col., Ibid., 1835.—*Des Papillons, ou Vade-mecum des Lépidoptèrologistes.* 8vo, fig., Paris, 1838. This author has also illustrated the entomology of the French possessions in Northern Africa, by figures and descriptions of many species of all the orders, in the third volume of the great work published by the government on the *Exploration Scientifique de l'Algerie.*

Rudolph von Jenison-Walworth. *Die Insekten-Doubletten aus der Sammlung des.* 8vo. München, 1834.—*Reise durch Süd-Deutschland, u. Nord-Italien.* 8vo, Ibid., 1835.

Eb. Munck af Rosenschold. *Prodromus faunæ, Coleopterorum Lundensis.* 8vo, Præs., 1835.

G. G. Kollar. *De Cicindela Campestri.* 4to, Gotting., 1836.

Gustave Silbermann. To this author we owe numerous excellent articles in the *Revue Entomologique* of Strasbourg (1833 et seq.), a useful publication containing original essays, and descriptions of species, with critical and explanatory notices of recent entomological works, chiefly those of France and Germany. He has also written *Enumération des Entomologistes Vivants.* 8vo, Paris, 1835. This is a work in which those whose names are now inscribed desire to be continued in future editions.

Fr. Herold. *Entwickelungsgeschichte der Schmetterlinge, Anatomisch*, &c. 2 vols. 4to, fig., Kassel, 1815.—*Von der Erzengung der Insecten.* Folio, Frankf., 1834.

M. Poey has written a work named *Centurie des Lépidoptères de l'Isle de Cuba.* Pl. col., Paris, 1834.

J. G. Gebhardt. *Die Schädlichen Feld, Wald u. Obstbaum Insecten*, &c. 8vo, Hanover, 1834.

L. P. Cantener. *Catalogue des Lépidoptères du Dép. du Var.* 8vo, Paris, 1833.—*Hist. Nat. des Papillons diurnes des Dép. du Haut et Bas Rhin*, &c. 8vo, Par. et Colm., 1835.

M. Carrara. *Sulla Fosforescenza della Lucciola commune* (*Lamp. Italic.*). 8vo, Milano, 1836.

Toussaint de Charpentier. *Verzeichniss der Europaischen Schmetterlinge in Besug auf Hübner's Schmetterlingswerk.* Breslau, 1818.—See preceding notice of M. Charpentier's Works, p. 13.

W. de Haan. *Mémoire sur les Métamorphoses des Coléoptères.* 4to, Paris, 1836.

—— Bernard Deschamps. *Recherches Microscopiques sur l'organization des ailes des Lépidoptères.* 8vo, Paris, 1835.

Le Comte Dejean, a peer of France, and lieutenant-general, now deceased, was one of the most noted collectors of Coleoptera in modern times. He published the *Catalogue des Coléoptères de sa Collection.* 3d ed., 8vo, Paris, 1837-38. This work is interesting as exhibiting the amount of species in each genus and as indicating their localities. *Spécies générale des Coléoptères.* 6 vols. in 7, 8vo, Paris, 1825-39.—*Iconographie et Hist. Nat. des Coléoptères d'Europe.* 8vo, fig., 5 vols. 1829-40. In this work our author was aided by MM. Boisduval and Aubé. The first four volumes contain the Carabiques, and consist of 46 fasciculi, with 223 coloured plates. The fifth volume (by M. Aubé) contains the *Hydrocanthares*, and is composed of 10 fasciculi, with 41 coloured plates.

A. De la Rue. *Entomologie forestière*, &c., &c. 8vo, Paris, 1838.

F. L. Delaporte De Castelnau. *Etudes Entomologiques*, &c. 8vo, Paris, 1834-35.—*Essai d'une classification de l'ordre des Hemiptères.* 8vo, Paris.—*Traité élémentaire d'Entomologie.* 12mo, Paris, 1839. In union with Mr Gory, he has given us *Hist. Nat. et Iconog. des Insectes Coléoptères*; 2 vols. 8vo, Paris, 1835-40;—*Monographie des Buprestides;* 8vo, fig., col., Ibid., 1834; and—*Monographie du genre Clytus;* 8vo, fig., col., Ibid., 1835. To M. Delaporte we are also indebted for numerous papers in Guérin's *Mag. de Zoologie*, the *Ann. de la Soc. Ent.*, and Silbermann's *Revue.*

L. Gory has contributed largely to entomology in Guérin's *Magazine de Zoologie*, and, in conjunction with M. Delaporte, is the author of *Monographie des Buprestides.* Paris, 1834. With that observer he has also executed a *Monographie des Genres Clytus*, and the *Hist. Nat. et Iconog. des Insectes Coléoptères*, 2 vols. 8vo, Paris, 1840; while with M. Percheron he has published a *Monographie des Cetoines et genres voisins*, &c., Paris, 1833-36.

A. R. Percheron. Besides the works above alluded to, this author has executed a *Monographie des Passales, et des genres qui en ont été séparés.* 8vo, Paris, 1835. He has contributed to Guérin's *Mag. de Zool.*, and is joined with that writer in his *Genera des Insectes.* 8vo, Paris, 1831-35. He has also written *Bibliographie Entomologique.* 2 vols. 8vo, Paris and London, 1837.

J. Th. Lacordaire. *Essai sur les Coléoptères de la Guyane Français, Nouv. Ann. des Trans.* Tom. ii., p. 35. —*Introduction à l'étude d'Entomologie*, &c. 2 vols. 8vo, fig., Paris, 1834-37.—*Monographie des Erotyliens.* 8vo, Paris, 1842.—*Revision de la famille des Cicindélides.* 8vo, Liège, 1842.—*Monographie des Coléoptères subpentamères de la famille des Phytophages.* In the *Mém. de la Soc. Royale de Liège.* Tom. iii. v., Brux., 1845. These volumes have since been published apart. They contain descriptions of the species of *Crioceris*, *Lema*, *Sagra*, *Donacia*, *Megalopus*, *Clythra*, *Chlamys*, *Lamprosoma*, and allied genera. It is almost appalling to the entomologist to consider the dimensions to which a descriptive catalogue of even the phytophagous coleoptera must extend when completed. M. Lacordaire has made many more special contributions to our science, and is the joint author (with M. Boisduval) of the *Faune Entomologique des Environs de Paris.* 1 vol. 18mo, Paris, 1835. But perhaps the most important of our present author's works is his general one, the *Histoire des Insectes*, now publishing in the *Nouvelles Suites* à Buffon. The first two volumes have appeared. The work professes to be an "Exposé méthodique et critique de tous les genres proposés jusque ici." He gives the characters of each genus, and appends a list of all the species yet described. This work is of great value, not only for classification and characters, but for general information on all that the author touches. He professes to make the entomological world aware of what is really known up to the present time,—a bold and ambitious attempt, but as likely to prove successful in the hands of M. Lacordaire as in those of any other.

Bibliography.

J. C. Chenu. This author is now (1855) carrying on an *Encyclopédie d'Histoire Naturelle*, which, like others under that name, is necessarily a compilation. It already contains two volumes on Coleopterous insects, and the like number upon the Lepidopterous order. Each volume contains many hundred figures (woodcuts), with a representation of almost every genus. The different departments of the work may be had separately, and are remarkable for the smallness of their cost.

Max. de Chaudoir. *Tableau d'une nouvelle subdivision du genre Feronia*, Dejean, *suivi d'une caracteristique de trois nouveaux genres de Carabiques*. Bull. Mosc. Rev. Zool., 1839, p. 26.—*Genres nouveaux, et espèces nouvelles des Coléoptères de la famille des Carabiques*. Ibid. p. 27. —*Enumeration of the Carabidæ and Hydrocantharidæ of the Caucasus*. Kiew, 1846.

—— Gaubil. *Quelques Carabiques nouveaux pour la Faune de la France et de nos possessions d'Algerie*. Rev. Zool., 1844.—*Catalogue synonymique de Coléoptères d'Europe et d'Algerie*. 8vo, Paris, 1850.

M. Audinet-Serville, a labourer in the entomological portions of the *Faune Française*, and of the *Encyclopédie Méthodique*, published the last fasciculus of the work by the late Palisot de Beauvois, on the *Insectes recueillis en Afrique et en Amerique*, already mentioned. He is also the author of a *Nouvelle Classification de la Famille des Longicornes*, in the *Annales de la Société Entomologique de France*, 1833-4.—*Tableau Méthodique des Insectes de l'ordre des Orthoptères*. 8vo, Paris, 1831.—*Insectes Coléoptères*. 8vo, Ibid. 1831.—*Sur une Lettre de Westermann, sur les Mœurs d'Insectes des Indes Orientales et du Cap de Bonne Espérance*. 8vo, Paris.—*Revue Méthodique des Insectes Orthoptères*. Ann. Sc. Nat., xxii.—*Hist. Nat. des Insectes Orthoptères*. 8vo, Paris, 1839.—With M. Amyot, *Insectes Hemiptères*, in *Suites à Buffon*.

H. M. Asmuss. *Monstrositates Coleopterorum*. Rigæ, 1835.

A. Chevrolat. *Coléoptères de Mexique*. 8vo, Strasb. 1834.—*Coléoptères de Syrie*. 8vo, Paris, 1854. To this author we also stand indebted for numerous articles in Guérin's *Mag. de Zool.*, and Silbermann's *Revue Entom.*

Ch. Aubé. *Considérations sur la Gale, et l'Insecte qui la produit*. 8vo, Paris, 1836.—*Monographia Pselaphiorum, cum Synonymiâ extricata*. 8vo, fig., Paris, 1834. M. Aubé is also the author of that portion of Comte Dejean's *Spécies général des Coléoptères*, which relates to the *Hydrocantheres et Gyrinites*. 1 vol. 8vo, Paris, 1838; as well as of the 5th volume of Dejean and Boisduval's *Iconographie des Coléoptères d'Europe*. 8vo, Paris, 1836.

Steph. Auboin. *Entomologie, ou Traité des Insectes*. 2 vols. 18mo, Paris, 1831.

George Robert Gray has contributed largely to many departments of natural history, and described numerous new insects of all orders in Griffith's translation of Cuvier's *Animal Kingdom*, 8vo, 1829. We have also from the same author *Descriptions and figures of some new Lepidopterous Insects, chiefly from Nepaul*. 8vo, pl., 1846.—*The Entomology of Australia, in a series of Monographs*. Part 1st (*Phasma*), 4to, London, 1833.—*Synopsis of Insects belonging to the Family of Phasmidæ*. 8vo, Lond. 1835. Mr Gray has more recently published a very handsome volume on the Papilionidæ of the British Museum, with many figures of new species. This forms one of the series of Catalogues by his brother, Dr John Edward Gray (whose varied and valuable works on natural history we do not here name, as they belong to other departments of the science), prepared by direction of the trustees.

Adam White, zoologist attached to the British Museum, has contributed largely to various departments of natural history. We shall here name—*Nomenclature of Coleopterous Insects in the British Museum* (*Cetoniadæ*). Lond. 1847.—*Nomenclature of Coleopterous Insects in do.* (*Hydrocanthari*). Ibid. 1847.—*Nomenclature of Coleopterous Insects in do.* (*Buprestidæ*). Ibid. 1848.—*Nomenclature of Coleopterous Insects* (*Cleridæ*), *with descriptions of* 28 *unrecorded species*. Ibid. 1849.—*Catalogue of Longicorn Coleoptera, with descriptions of apparently unnoticed species in the British Museum*. Part 1, figures. Mr Adam White has moreover contributed many excellent special articles to Maunder's *Treasury of Natural History*, 8vo, Lond. 1849 (3d edit., ibid. 1854), and has added to our knowledge of new species in the appendix to Captain Grey's *Western Australia*, Lond. 1841; and in those of Eyre's *Central Australia*, Ibid. 1845; of the *Voyage of H.M.SS. Erebus and Terror*, Ibid. 1846; of Dieffenbach's *New Zealand*; of Stokes's *Discoveries in Australia*, Ibid. 1846; of Macgillivray's *Voyage of H.M.S. Rattlesnake*, Ibid. 1852. He has figured and described *Longicorn Beetles*, in the illustrated *Proceedings of the Zoological Society*. An ample and accurate list of his writings will be found in Agassiz and Strickland's *Bibliographia Zoologica*, vol. iv. p. 557.

Francis Walker was the principal editor of the *Entomological Magazine*, 5 vols. 8vo, London, 1833-37, and has contributed many papers to that work, and also to the *Ann. and Mag. of Natural History*, and other periodicals. Of separate works he has published—*Monographia Chalciditum*. 2 vols. 8vo, London, 1839.—*Insecta Saundersiana*. Two parts of this work are devoted by Mr Walker to the description of Diptera in the collection of Mr W. Wilson Saunders.—*British Diptera* (in the *Insecta Britannica*). Of this work two volumes have appeared, and a third is (1855) in the press.—*Catalogue of Neuroptera in British Museum*. 4 parts, Lond. 1853. (We may here note that the majority of the catalogues now referred to contain descriptions of numerous new species.)—*Lepidoptera Heterocera*. 2 vols. Lond. This work contains the new species in the collection of the British Museum.—*Catalogue of Homoptera in the British Museum*. 4 parts, with figures, Lond. 1851.

W. S. Dallas. *Catalogue of Coreidæ in the British Museum*. Lond.—*Catalogue of Scutelleridæ and Pentameridæ in the British Museum*, with figures, Lond. 1851.

F. Smith. To this accurate observer we also owe some excellent catalogues of the entomological contents of the British Museum. Of the extensive and difficult family of Bees we have—Part I., *The Andrenidæ;* Part II., *The Apidæ;* with descriptions of many new species, and illustrated by outline figures of the genera, with details.—*Catalogue of the Hymenopterous Insects of the families Mutillidæ and Pompilidæ*, describing many new species in the Museum collection.—*Monograph of the British Bees*, illustrated with plates. This work also forms a portion of the great series of Museum catalogues now in course of publication by Dr Gray, the keeper of the zoological department. Mr Smith has contributed many papers to the *Zoologist*, and the *Ann. and Mag. of Nat. Hist.*

Edward Doubleday. This author, whose decease we have now to mourn, had acquired a remarkable knowledge of insects of the Lepidopterous order. He contributed largely to the *Entomological Magazine*, and other scientific periodicals, and described the *Lepidoptera* in the volumes which Stokes and Eyre have respectively devoted to the narrative of their *Discoveries in Australia*, as well as the insects of the same order in the appendix to Dieffenbach's *New Zealand*. He formed the published *Catalogue of the Lepidopterous Insects in the British Museum*. Part I., 1844; Part II., 1847. In union with Mr Hewitson, he was the author of *The Genera of Butterflies, or Diurnal Lepidoptera; comprising their generic characters, a notice of their habits and transformations, and a Catalogue of the species of each genus*. Illustrated with 86 coloured plates

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from drawings by W. C. Hewitson. 2 vols. imperial 4to. Lond. 1846–49. In this admirably illustrated work Mr Westwood was also a collaborateur.

Henry Doubleday. *List of British Lepidoptera.* 8vo, Lond. 1847.

H. Burmeister. *De Insectorum systemate naturali.* Hallæ, 1829.—*Handbuch der Entomologie.* 4 vols., Berlin, 1832–47. The general portion (*Algem. Entomol.*) of this invaluable work has been translated by Mr Shuckard under the title of *A Manual of Entomology.* 8vo, Lond. 1836. Of the other volumes, one is devoted to *Hemiptera,* another to *Neuroptera* and *Orthoptera,* and the others to the *Lamellicorn Coleoptera.*—*Genera Insectorum, iconibus illustravit et descripsit.* 8vo, Berol. 1838–46.—*Bemerkungen über den allgemeinen Bau und die Geschlechtsunterschiede bei den Arten der Gattung Scolia.* Mit. 1 tafel. 4to, Halle, 1854.—*Uebersicht der Brazilianischen Mutillen.* 4to, Ibid. 1854.—*Untersuchungen über die Flügeltypen der Coleopteren.* Ibid. 1854.

W. E. Shuckard has made the following contributions to entomology:—*Essay on the indigenous fossorial Hymenoptera, comprising a description of all the British species of Burrowing Sand-Wasps contained in the Metropolitan Collections.* 8vo, Lond. 1837.—*Elements of British Entomology, containing a general introduction to the Science,* &c. 8vo, Lond. 1839.—*The British Coleoptera delineated* (with 94 plates by W. J. Spry). 8vo, Lond. 1840.—*On the habits of the Aculeate Hymenoptera: Trans. of Ent. Society,* i. p. 52. Besides being the author of many other descriptive papers in various scientific journals, he has contributed an essay on the *Progress and Prospects of Entomology* to the 29th No. of the *For. Quar. Rev.* In conjunction with Mr Swainson, he is the author of a volume on *The Natural History and Arrangement of Insects* in Dr Lardner's *Cyclopædia* (Lond. 1840), and to him we also stand indebted for a translation (as above mentioned) from the German of Burmeister's *Manual of Entomology.* 8vo, 1836.

W. O. Westwood, a skilful entomologist and accurate draftsman, whose writings and illustrations are voluminous and of great value. Referring to the 4th vol., p. 549, of the *Bibliographia Zoologica,* for a list of his separate papers in the *Trans. of the Entom. Society,* and the *Ann. and Mag. of Nat. Hist.,* we shall here confine ourselves to the indication of his principal works:—*Address on the recent progress and Present State of Entomology.* 8vo, Lond. 1835. —*Catalogue of Hemiptera in the Collection of the Rev. F. W. Hope.* 8vo, Lond. 1837.—*The Entomologist's Text-Book.* 8vo, fig., Lond. 1838.—*An Introduction to the Modern Classification of Insects, founded on the Natural Habits and corresponding organisation of the different Families.* 2 vols. 8vo, fig., Lond. 1839–40.—*British Butterflies and their transformations exhibited in a series of 42 coloured plates, by H. N. Humphreys.* Demy 4to, London, 1841.—*British Moths and their transformations, arranged and illustrated in a series of plates, by H. N. Humphreys.* Demy 4to, London, 1843–45.—*Cabinet of Oriental Entomology.* 4to, London. In this work many of the more showy insects of India and the Asiatic Islands are figured and described.—*Arcana Entomologica, or Illustrations of new, rare, and interesting Exotic Insects.* 8vo, fig., Lond. 1841-42. Mr Westwood was connected editorially with the republication of Drury's *Illustrations of Exotic Entomology* (3 vols. 4to, Lond. 1837,) and has added notes and systematic names. He recently communicated a paper, entitled *Contributions to Fossil Entomology,* to the *Trans. of the Geological Society,* London, 1854.

—— Fortier. *Observations sur le Puceron lanigère.* 12mo, 1835.

Fr. Faldermann. *Coleopterorum ab ill. Bungio in China bor., Mongolia,* &c., *Missorum Illustrationes.* 4to, fig. Petrop. 1835.—*Fauna Entomologica Trans. Caucassia.* 2 vols., 4to, fig., Mosqu. 1836-37.

James Wilson. *A Treatise on Insects, general and systematic, being the Article "Entomology" from the 7th Edition of the Encyclopædia Britannica.* 4to, with plates, Edin. 1835. The same author (in conjunction with Mr Duncan) has published *Entomologia Edinensis, or a description of the Insects found in the neighbourhood of Edinburgh.* (Coleoptera.) Edin. 1834.

James Duncan. In addition to his aid in the work last named, this author has contributed the following volumes (published in 1834–42) to Sir William Jardine's Naturalist's Library. *Introduction to Entomology; comprehending a general view of the metamorphoses, external structure, anatomy, physiology, and systematic arrangement of all classes of Insects,* with 38 coloured plates.—*The Natural History of Coleopterous Insects,* with 32 coloured plates.—*The Natural History of British Butterflies,* with 36 coloured plates. —*British Moths and Sphynxes,* with 32 coloured plates.—*Foreign Butterflies,* with 33 coloured plates.—*Exotic Moths,* with 34 coloured plates.

B. A. Carlson. *Prodromus Hymenopterologiæ Scandinaviæ.* 8vo, Lundæ, 1836.

C. A. A. Buhle. *Raupen-u. Schmetterlingskalender der Deutschen Falter.* 4to, Leipz. 1837.—*Die Tag-u. Abendschmetterlinge Europas.* 4to, Ibid. 1837.

J. D. Labram. *Insecten der Schweiz.* 2 vols., fig. col., Basel, 1836-38. — *Singulorum Generum Curculionidum Icones.* 8vo, Ibid. 1842–50.—The latter is conjointly with M. Imhoff.

C. Wesmael. This author's contributions to entomology are to be found chiefly in the *Bulletins des Sciences de l'Acad. royale de Bruxelles.* Of his separate works we may name the following:—*Monographie des Braconides de la Belgique.* 3 vols. 4to, fig., Brux. 1835-37.—*Monographie des Odynères de la Belgique.* 8vo, fig., Ibid. 1835.—*Revue critique des Hyménoptères fouisseurs de Belgique.* 8vo, Bruxelles, 1851–52.

Osw. Heer. *Geographische Verbreitung der Käfer in den Schweizeralpen.* 8vo, Zurich. 1834.—*Observationes Entomologicæ continentes Metamorphoses Coleopterorum nonnullorum adhuc incognitas.* 8vo, fig., Tur. 1836.—*Fauna Coleopterorum Helvetica.* P. I, 8vo, Tur. 1838.—*Die Käfer der Schweiz, mit besond. Berücksichtig. ihrer geograph. Verbreitung zusammengestellt.* 3 vols. 4to, Neuchatel, 1839-41.—*Ueber Verbreitung und Vertilgung der Laubkäfer und Inger.* 8vo, Zurich, 1843.—*Ueber die Haus-Ameise Madeira's.* 4to, Zurich, 1852.

F. W. Hope, a noted English collector, whose entomological museum was one of the largest in Britain. We believe it has now been consigned to the University of Oxford. Mr Hope has published—*Description of the Buprestidæ* (in his own collection). 8vo, Lond. 1836.—*A Catalogue of Hemiptera* (in his own collection) *with short Latin descriptions of the new species.* 8vo, Lond. 1837.—*The Coleopterist's Manual,* Part I., *containing the Lamellicorn Insects of Linnæus and Fabricius.* 8vo, pl., Lond. 1837. The same, Part II., *containing the predaceous Land and Water Beetles of Linn. and Fab.* 8vo, pl., Ibid. 1838-45.— The same, Part III., *Various Beetles.* 8vo, pl., Ibid. 1841.

E. Heeger. *Beiträge zur Schmetterlingskunde oder Abbildung und Beschreibung neuer Sicilianischer Schmetterlinge.* 4to, fig., Wien, 1838.—*Beiträge zur Naturgeschichte der Insecten.* 12 Parts, Royal 8vo, Vien. 1854.

M. H. Dupont. *Monographie des Trachydérides de la famille des Longicornes.* 8vo, fig., Paris, 1839. This observer has described many fine insects in Guerin's *Mag. de Zool.,* for the years 1832-33.—*Beiträge zur Naturgeschichte der Insecten.* 10 Fortsetzung. Mit 6 tafeln. 8vo, Wien, 1853.

E. Menetries. *Catalogue d'Insectes recueillis entre*

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Constantinople et le Balkan. 4to, fig., Peterb. 1838.—*Essai d'une Monographie du genre Anacolus.* 4to, Ibid. 1839.—*Descriptions des Insectes recueillis par feu M. Lehmann.* 4to, Ibid. 1848. By the same author, we have other papers in the *Mem. Acad. Peterb.*, &c.

J. F. MENETRIES. *Catalogue de quelques Lépidoptères des Antilles; avec la description de plusieurs espèces nouvelles.* 4to, Moscou, 1833.

L. ALTMANN. *Abriss der Entomologie.* 8vo, Leipz. 1837.—*Die nützlichen u. schädlichen Forstkäfer für Forstbeamts.* 8vo, Dessau, 1844.

JOH. GISTL. *Enumeratio Coleopterorum agri Monacensis.* 8vo, 1831.—*Systema Insectorum secundum classes, ordines,* &c. Tom. I., *Coleoptera,* Fascic. 1st, *Mantichora –Dromica.* 1837. Fascic. 2d, *Cicindela–Cymindis.* 1840.—*Die Entomolgen Europas.* Munch. 1834.—*Hemipteren und Orthopteren Fauna der Schweiz.* 1838.—*Lexicon der Entomologischen Welt, der carcinologischen u. arachnologischen, Addressbuch der lebenden Entomologen u. Entomophilen,* &c. 8vo, Stuttgart, 1847.

C. F. FREYER. *Beiträge zur gesch. Europäischer Schmetterlinge.* Nurnb. 1828-31.—*Neuere Beitrage zur Schmetterlingskunde.* 4to, Augsb. 1831-46.—*Die Schädlichsten Schmetterlinge Deutschlands, für Forstmänner,* &c. 8vo, Ibid. 1839.

ANT. CORNOLLI. *De Coleopteris novis ac rarioribus minusve cognitis, Provinciæ Novocomensis.* Ticini Reg., 8vo, 1837.

CHANOINE D'AVRILLY. *Du Myzoxile, Puceron lanigère.* 8vo, fig., Louviers, 1834.

F. M. G. DE TIGNY (and ALEX. BRONGNIART). *Histoire Naturelle des Insectes, redigee suivant les methodes d'Olivier.* 10 vols. 18mo, Paris, 1799-1832. There is an edition by Guerin, Paris, 1828, and also an Italian translation, 3 vols. 8vo, Livorno, 1835.

P. CONGLIANI. *Remarques sur la Faune Entomologique des environs de Reggio.* Esercit. Acc. 1839.

C. F. CONSTANT. *Hist. Nat. des Papillons.* 16mo, fig., Paris, 1839.

HENRY DENNY. *Monographia Pselaphidorum et Scydmænidarum Britanniæ.* 8vo, fig., Norwich, 1825.—*Monographia Anoplurorum Britanniæ,* &c. 8vo, fig., Lond., 1841–42.

—— DEVILLERS. To this author (conjointly with M. Guenée) we owe *Tableaux Synoptique des Lépidoptères d'Europe, contenant la description de tous les Lépidoptères connus jusqu'à ce jour.* 4to, Paris, 1835.

GUIL. FERD. ERICHSEN. *Genera Dytiscorum.* 8vo, Berol. 1832.—*Die Käfer der Mark Brandenburgh.* 8vo, Berlin, 1837-39.—*Genera et species Staphylinorum Insectorum Coleopterorum familiæ.* 8vo, Berol. 1839-40.—*Naturgeschichte der Insecten Deutschlands.* 8vo, Berlin, 1845.—*Entomographien Untersuchungen in d. Gebiete d. Entomologie, m. besonderer Benutzung d. Königl. Sammlung zu Berlin,* 1840.—*Bericht uber d. wissenschaftl. Zeistungen im Gebiete d. Entomologie.* 9 Jahrgg. während d. Jahres 1838–47. Berlin, 1840–1848. Erichsen is the author of many entomological essays in various Continental periodicals. He has also described the insects of British Guiana in the third volume of Richard Schomburgh's *Reise,* and those of Peru in Wiegmann's *Archiv.* His writings are of great value, and his untimely death was an irreparable loss to the science which he so assiduously and successfully cultivated.

ED. EVERSMANN. *Libellulinæ inter Wolgam et Montes Uralenses.* 8vo, Mosquæ, 1836.—*Fauna Lepidopterorum Volgo-Uralensis exhibens Lepidopterorum species quas per vigenti quinque annos in Provinciis Volgam fluvium inter et montes Uralenses sitis observavit et descripsit.* 8vo, Casani, 1844.

FEL. DUJARDIN. The only separate work of this frequent contributor to the *Ann. des Sciences Nat.*, &c. with which we are acquainted, is his *Promenades d'un Naturaliste—Insectes.—Entretiens familiares,* &c. 18mo, fig. Paris, 1838.

LUCIEN BUQUET. To this author we owe many contributions to the *Ann. de la Soc. Ent.* and other periodicals. *Rev. Zool.* 1838-40.

G. R. WATERHOUSE has contributed many papers on Insects to the *Trans. of the Entom. Society* (1840-41), the *Ann. and Mag. of Nat. Hist.*, and other works.

W. C. HEWITSON. To this author (well known for his work on the Eggs of British Birds) we owe several entomological papers in the scientific periodicals, and he has published many Fasciculi of *Exotic Butterflies, being illustrations of new species, selected chiefly from the collections of W. Wilson Saunders and W. C. Hewitson.* 4to, Lond. 1851–54. In this work he figures and describes entire groups, especially of the diurnal Lepidoptera of South America. He was conjoined with Mr Doubleday in his beautiful *Genera of Diurnal Lepidoptera.* 2 vols. Lond. 1846-49.

EDWARD NEWMAN is the author of numerous special papers on entomological subjects. These have appeared chiefly in the 2d series of the *Magazine of Nat. Hist.*, in the *Entomological Magazine,* the *Entomologist,* and the *Zoologist,* of which last two periodicals he was the conductor. His separate works on Insects are *Sphynx Vespiformis, an Essay.* 8vo, Lond. 1832. A second edition was published under the title of *System of Nature.* 8vo, Lond. 1843.—*The Grammar of Entomology.* 12mo, Lond. 1835.—*A Familiar Introduction to the History of Insects.* 8vo, 1841.—*Proposed Division of Neuroptera into two classes.* 8vo, Lond. 1853.

G. A. W. HERRICH-SCHAEFFER. *De Generatione Insectorum,* &c. Fig. Ratisb. 1821.—*Nomenclator Entomologicus,* &c. 8vo, Regensb. 1835-1840.—*Die Wanzenartigen Insecten.* 8vo, Nurnb. 1836-46. This work now consists of several volumes, and every species described is also figured.—*Systemat. Bearbeitung der Schmetterlinge von Europa, als Text, Revision, und Supplement, zu J. Hubner's Sammlung Europaischer Schmetterlinge.* 5 vols. 4to, Regensb. 1843-45.—*Index alphabetico-synonymicus insectorum hemipterorum heteropterorum. Alphabetisch-synonymisches Verzeichniss der wänzenartigen Insecten.* 8vo, Regensburg, 1853.—*Lepidopterorum exoticorum species novæ aut minus cognitæ. Collection de nouvelles espèces de papillons exotiques,* Serie 1, Livraisons 1–17. 4to, Regensburg, 1855. Our present author, as already noted, is the continuator of Panzer's *Deutschland Insecten.*

GEORGE NEWPORT. We have not many works of this author published apart, but he has of late years made some valuable additions to our knowledge of the physiology of Insects. These are to be found chiefly in the *Proceedings and Transactions* of the Royal, Linnæan, and Entomological Societies of London. His separate publications are,—*Observations on the Anatomy, Habits, and Economy of Athalia centifolia, the Saw-fly of the Turnip, and on the means of preventing its ravages.* 8vo, Lond. 1838.—*An Address delivered at the Anniversary Meeting of the Entomological Society.* 8vo, Lond. 1844.—*An Address delivered at the adjourned Anniversary Meeting of the Entomological Society.* 8vo. Lond. 1845.—Mr Newport has, moreover, contributed the article *Insecta* to Todd's *Cyclopædia of Anatomy and Physiology.* Vol. iv. pp. 853-994.

NIC. CONTARINI. *Memoria sopra una nuova specie di Cecidomia, ed alcuni Osservazione sopra quella dell' sperico.* 4to, fig. Venez. 1840.—*Cataloghi degli Uccelli e degli Insetti di Padoua e Venezia.* 4to, Bassona, 1843.—*Discorso sull' utilità dello Studio degli Insetti.* Atti de Aten. Venez. ii. p. 3.

BALTHASAR E. DE ROMAUD. *Tableau de l'aile superieuse des Hymenopteres.* 4to, Paris, 1839.

E. MULSANT. *Lettres à Julie sur l'Entomologique* (en

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prose et en vers) suivies d'une description méthodique de la plus grande partie des Insectes de France, ornée de 15 pl. 2 vols. 8vo, Lyon, 1830–31.—*Cours d'Entomologie, reduit en tableaux synoptiques ; à l'usage des Ecoles.* 8vo, Lyon, 1833.—*Histoire Naturelle des Coléoptères de France:* 1re Partie, *Longicornes.* 8vo, 3 pl., Lyon, 1839. La même, 2e Partie, *Lamellicornes.* 8vo, pl., Lyon, 1842. La même, 3e Partie, *Palpicornes.* 8vo, Lyon, 1843.—*Securipalpes de France.* 1 vol. 8vo, Paris, 1842.—*Hist. Nat. des Coléoptères de France: Sulcicoles Récurvipalpes.* 8vo, Paris, 1846.—*Opuscules Entomologiques.* 1–4 cahiers, 8vo, Paris, 1853. M. Mulsant has moreover recently published a *Monograph of the Coccinellidæ.* It appeared originally in the *Annal. des Sciences Physiques,* &c., of Lyons.

H. A. HAGEN. *Synonymia Libellulorum Europæorum.* 8vo, Kœnigsb. 1840.

EM. BLANCHARD. *Histoire des Insectes* (Suite à Buffon —Dumeril), III. *Orthopt. Neuropt. Hemipt. Hymenopt. Lépidopt. et Dipt.* Paris, 1840.—*Hist. Nat. des Insectes, traitant de leurs mœurs,* &c. 8vo, Paris, 1845. With MM. Hombron and Jacquinot, M. Blanchard has described and figured many insects from Australia and the Asiatic islands in D'Urville's *Voyage a la Pole Sud.—Catalogue of Insects* in the Paris Museum.

ADR. ANTELME. *Hist. Nat. des Insectes et des Mollusques.* 2 vols. 8vo, Paris, 1841.

HERM. SCHAUM has published *Symbolæ ad Monographiam Scydmænorum ; Dis. Inaug.* 8vo, fig., Halis, 1841. —*Analecta Entomologica.* 8vo, Halis Sax., 1841.—*Verzeichniss der Lamellicornia Melitophila.* Stettin, 1848.—*Bericht über die Wissenschaftlichen Leistungen im Gebiete der Entomologie während des Jahres* 1848. 8vo, Berlin, 1850.—The same for 1849. Berlin, 1850.—The same for 1850. Berlin, 1852.—The same for 1851. Berlin, 1853.—The same for 1852. Berlin, 1854.

H. R. HUMPHREYS. This author, conjointly with Mr Westwood, has published on *British Butterflies and their Transformations.* 1 vol. 4to, col. pl., London, 1841 ; and on *British Moths.* 2 vols. 4to, Ibid. 1843-45.

SELYS DE LONGCHAMPS has, among other works, published the following: *Catalogue des Lépidoptères et Tableau des Libellulines de la Belgiques.* 8vo, Liège, 1837.—*Monographie des Libellulidées d'Europe.* 8vo, Paris, 1840.—*Enumération des Insectes Lépidoptères de la Belgique.* In *Mem. de l'Acad. de Liège,* 111.—*Revision of the British Libellulidæ.* In *Ann. Mag. of Nat. Hist.* xviii. p. 217.—*Liste de Libellules d'Europe et diagnose de quatre espèces nouvelles.* In *Rev. Zool.,* 1848.

JOHN WALTON has contributed several papers, chiefly on the *Curculionidæ,* to the *Ann. Mag. of Nat. Hist.,* &c.

J. S. BOWERBANK. We owe to this author observations on the circulation of the blood in insects, and other papers in the *Entomological Magazine,* &c. He is an excellent microscopical observer.

JAMES HARDY. This pains-taking and accurate observer has contributed to the *Proceedings* of the *Berwickshire Naturalists' Club,* and (with Mr Bold) has published a *Catalogue of the Insects of Tyneside and Durham. Trans. of Tyneside Nat. Field-Club,* i. 37.

F. ISNARDI. *Storia del Papilio Jasius, e della Seta che si più ticavare del suo Baso.* 4to, fig., Genova, 1840.

T. W. HARRIS. *Report on the Insects of Massachusetts injurious to Vegetation.* 8vo, Camb. U.S., 1841–2.—Various papers in Silliman's *Journal,* &c.—Conjointly with LE CONTE, Dr Harris has described the insects in Agassiz's work on *Lake Superior.* Boston, 1850. He has written *A Treatise on some of the Insects of New England which are injurious to Vegetation.* 8vo, Boston, 1852.

BOYER DE FOSCOLOMBE. *Des Insectes Nuisibles à l'Agriculture.* 8vo, fig., Aix, 1840. He has contributed various papers to the *Annales de la Soc. Ent.*

T. VICTOR. *Insectes du Caucase* (Bulletin de Mosc., 1840).—*Coléoptères du Caucase* (Ibid).

FR. BERGE. *Schmetterlingsbuch od. Naturgesch. der Schmetterlinge, mit* 1100 *illum. abbildgn, gr.* 4to, Stuttgart, 1842.—*Kaferbuch Naturgesch. der Käfer, mit* 1315 *illum.* abbildgn. 4to, Stuttgart, 1844.—*Insetti osservati nel periodo dell' eclisse del* 8 *Luglio,* 1842. 12mo, Milano, 1842.—*Catalogo dei Coleopteri della Lombardia.* 8vo, Milano, 1844.

J. J. BOURASSÉ. *Esquisses Entomologiques.* 12mo, Tours, 1842–44.

F. DE BREME. *Monographie de quelques genres Coleoptères, Hétéromères, appartenant à la tribu des Blapsides.* 12mo, fig., Paris, 1842.—*Essai monog. et iconog. de la tribu des Cossyphides.* 8vo, pl. col., Paris, 1842.

C. R. WULFF. *De Fabrica corporis Insectorum Diss.* 8vo, Lundæ, 1842.

M. T. BOITARD. *Manuel d'Entomologie, ou Hist. Nat. des Insectes.* 2 vols. 18mo, Paris, 1843.

CHR. KEFERSTEIN. To this author we owe various articles in Silberman's *Revue Entomologique.*

L'ABBÉ BOURLET. *Mem. sur les Podurelles.* 8vo, Douai, 1843.

FR. GOLDFUSS. *Symbolæ ad Orthopterorum quorundam œconomiam.* Bonn, 1843.

P. JORAVKO. *Quelques remarques sur l'article du tarse des Hyménoptères, et* MANNERHEIM, *sur la récolte d'insectes Coléoptères faite* 1843. (Bulletin de Mosc.)

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CARL. H. BOHEMAN has published *Novæ Coleopterorum species descriptæ.* N. Mem. Nat. Moscou, i., p. 101.—*Caladromus genus è familia Curculionidum.* Mèm. Ac. Stockh. 1837.—*Monographia Cassididarum.* 2 vols., cum tabulis, 8vo, Holmiæ, 1850.—*Insecta Caffrariæ annis* 1838 1845, *a T. A. Wahlberg collecta amici auxilio suffultus, descripsit.* 8vo, Holmiæ, 1851. There are now two volumes of this work, containing descriptions of a great number of Coleopterous families. We may here enumerate them, with a view to exemplify the geographical distribution of South African insects:—Buprestides, Elaterides, Cebrionites, Rhipicerides, Cyphonides, Lycides, Lampyrides, Telephorides, Melyrides, Clerii, Teredites, Ptiniores, Palpatores, Silphides, Histeres, Scaphidiliæ, Nitidulariæ, Cryptophagidæ, Byrrhii, Dermestiori, Parnidæ, Hydrophilidæ.

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ACHILLE COSTA. *Ragguaglio delle specie più interessanti di Emitteri eterotteri raccolti in Sicilia,* &c. Esercit. Acc. 1839.—*Storia della Bombyce neustria, suoi costumi, danni che arrecal, e mezzi per distruggerla, scritta per incarico del reale instituto d'incorraggiamento,* &c. 4to, Napoli, 1851.—*Storia della Tenthridine produtrice della gale delle foglie del Salcio.* (Salix Russelliana) 4to, Napoli, 1852.

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ANDREW MURRAY. This observer has devoted himself to the Coleopterous order, and has enlarged our knowledge of the North British indigenous species in his excellent and accurate *Catalogue of the Coleoptera of Scotland.* 8vo, Edin. 1853.

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LEOPOLD HEINRICH FISCHER. *Conspectus systematicus Orthopterorum Europæ.* 8vo, Lipsiæ, 1853.—*Orthoptera Europæa.* 1 vol. 4to, Leipzig, 1853. See also p. 14.

OTTO BREMER and WILLIAM GREY. *Beitrage sur Schmetterlings Fauna des nörlichen Chinás.* 4to, St Petersburg, 1853.

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JACQ. DUVAL et J. MIGNEAUX. *Genera des Coléoptères d'Europe.* Deyrolle, 1855. This beautiful work is being published in parts from time to time. They figure a species of each genus.

CLAUDIO GAY. *Historia di Chili. La Historia fisica y politica di Chili.* 8vo (with folio plates), 1853-54. In this sumptuous, though still unfinished work, 3 or 4 volumes are devoted to insects, in the hands of M. Blanchard and others.

T. V. WOLLASTON. *Insecta Madeirensia, being an account of the Insects of the Islands of the Madeiran group.* 4to, fig. col. Lond. 1854. This beautiful volume is one of the most valuable and praiseworthy contributions to entomology which has appeared in this country for a length of time. Under this head we may state that in

—— WEBB and BERTHELOT'S *Histoire Naturelle des Iles Canariens,* the insects of those islands are described by M. BRULLÉ.

—— MARSIEUL. This author is now in the course of publishing in the *Ann. de la Soc. Ent.* of France, an admirable *Monograph of the Histeridæ.*

LEON FAIRMAIRE et A. LABOULBÈNE. *Faune entomologique Française, ou description des Insectes qui se trouvent en France.* Tom. i., 16mo, Paris. 1854.

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CASPAR CZERNY. *Neuestes Schmetterlings-Büchlein. Eine genaue Beschreibung der bei uns am haufigsten vorkommenden Schmetterlinge. Für die Jugend bearbeitet.* Mit 18 colorirten abbildungen, 8vo, Wien.

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JAC. STURM. *Deutschland's Fauna.* Div. v., *Insecten;* part 22, *Coleoptèra.* 12mo, with 16 coloured plates. Nurnb. 1854.

A. G. DAHLBOM. *Hymenoptera Europæa.* 2 vols. 8vo, 1854. See also p. 17.

We shall now proceed to consider that great department in Zoology, the extent and importance of which are sufficiently indicated by the foregoing list of authors and their works.

ENTOMOLOGY.

Definition. **Entomology** (from ἔντομον, *insect*, and λογος, *discourse*), is that branch of natural science which treats of the history and habits of the insect tribes. Its subjects are the most numerous and diversified of any of those topics which engage the attention of the student of nature; and as they exemplify in a most surprising and admirable manner, both by their structure and instincts, the wisdom of the author and creator of all things, and form a highly interesting department of human knowledge, we deem their elucidation deserving of a lengthened dissertation.

The English term insect is no doubt derived from the Latin word *insectum* or *intersectum*, signifying *cut into* or intersected, in allusion to the obvious divisions of head, thorax, and abdomen, of which their general forms consist. The Greek word bears the same signification.

CHAPTER I.

DEFINITION OF INSECTS—THEIR ORDERS EXPLAINED—AND THEIR STUDY DEFENDED.

In the article Animal Kingdom of this work (see vol. iii. p. 192), we have given a view of the primary divisions of the subjects of zoological science. The third primary division, that of the articulated animals, consists of four great classes:—1. *Annelides*, such as serpulæ, nereids, leeches, earthworms, &c.; 2. *Crustacea*, such as crabs, lobsters, and shrimps; 3. *Arachnides*, such as spiders, scorpions, and mites; and 4. *Insecta*, or true insects, such as beetles, butterflies, and moths. The class Insecta of Linnæus included not only those last named, but also Crustacea and Arachnides, and was thus almost co-extensive with what we now regard as a primary division under the term *Articulata*. We have, however, already discussed those two branches as distinct classes, under their respective titles (see Arachnides and Crustacea), and we shall not repeat the important characters by which they are distinguished from genuine insects.

The term insect was anciently applied to a much more extended series of beings than are now included under that designation. It seems to have comprised whatever was destitute of an internal skeleton, and exhibited a body composed of articulated parts. In this sense it accords with its application in the writings of Aristotle and Pliny, with certain restrictions however, for these authors were in advance of their successors, in as far as they distinguished the Crustacea from insects. Swammerdam and Ray adopted the definition of the ancient authors, but erred in classing the Vermes or worms with insects, a combination which does not appear for certain to have entered into Aristotle's views. Linnæus wisely separated these two classes, but at the same time injudiciously joined the Crustacea with insects, placing them in his order *Aptera*, along with spiders and scolopendræ. Fabricius in that respect followed the same general plan, and included all those living creatures in the same class, notwithstanding the better example shown by Brisson, who had separated all the species possessed of more than six feet, that is, the Crustacea and Arachnides of Lamarck. Since the death of the great Swedish naturalist, our improved knowledge of the anatomy and physiology of the invertebrated classes has thrown a clearer light upon the subject, and many modifications have taken place in the arrangement of the insect tribes. Definition.

Insects, properly so called, may be defined as *animals without vertebræ, six-footed, with a distinct head furnished with two antennæ and a pair of composite immoveable eyes, and breathing through stigmatic openings which lead to interior tracheæ.*[1]

As we shall have occasion to mention many terms which may not be familiar to the general reader, we deem it advisable, instead of taking his knowledge for granted, to commence with a brief enumeration and explanation of the various *orders* in Entomology, so that their names, when subsequently brought forward, may be associated with some definite idea. We shall consider all insects as included under eleven different orders, as follows.

1. Coleoptera (from Κολεος, *a sheath*, and πτερα, *wings*), including all those kinds commonly called *beetles*. Their membranous wings, which are the true organs of flight, are protected by a superior and anterior pair of harder consistence, called elytra. They are all masticators, and are provided with mandibles and maxillæ. Pl. CCXXXIV–XL.

2. Orthoptera (from ορθος, *straight*, and πτερα, *wings*), including crickets, grasshoppers, locusts, &c. The upper wings are of the consistence of parchment, reticulated, and more or less incumbent. The mouth is provided with mandibles and maxillæ. Plate CCXLI.

3. Hemiptera (from ἥμισυ, *the half*, and πτερα, *wings*), including the cimices or bugs, the water scorpions, cicadæ or froghoppers, aphides, &c. A portion of their upper wings is frequently membranaceous, or of the same consistence as the inferior pair. The mandibles and maxillæ are replaced by a sheath and sucker. Plate CCXLII.

4. Neuroptera (from νευρον, *nerve*, and πτερα, *wings*), including libellulæ or dragon-flies, ephemeræ, &c. Both pairs of wings are membranous, naked, and finely reticulated. Mouth adapted for mastication, and furnished with mandibles and maxillæ. Plate CCXLIII.

5. Hymenoptera (from ὑμην, *a membrane*, and πτερα, *wings*), containing wasps, bees, ichneumon-flies, &c., and characterized likewise by membranous naked wings, which

[1] The above definition excludes those many-footed species called *Juli* and *Scolopendræ*, which, though still included by some modern writers among insects, were established as a distinct class by Dr Leach (*Edinburgh Encyclopædia*, vol. viii.; and *Linn. Trans.* vol. ix.) under the title of *Myriapoda*, and were recognised as such by Latreille in his *Familles du Règne Animal*, p. 322. Although we did not allude to this class in our exposition above referred to (art. Animal Kingdom), we think that the removal of the two genera just named from the Insecta is advisable, as it leaves the latter in a state to be more clearly defined, as well as actually composed of more natural constituent parts, or, as MM. Audouin and Milne Edwards have expressed it, *plus homogène*. "En effet," say these authors, "tous les animaux qui la composent alors ont le corps divisé en trois parties distinctes, une *tête*, un *thorax*, et un *abdomen*; trois paires de pattes sont fixées au thorax; souvent deux ou quatre ailes sont suspendues à la même partie; la tête porte deux *antennes* et deux yeux immobiles; la bouche est garnie d'une serie d'appendices modifiés pour broyer les alimens solides, ou pour pomper ceux qui sont liquides; un système particulier de vaisseaux sert à la respiration, et porte le nom de *trachées*; il existe un vaisseau dorsal qui n'est autre chose qu'un cœur rudimentaire; mais il n'y a point de véritable système circulatoire; les sexes sont distinctes; enfin, la plupart de ces êtres éprouvent, pendant les premiers temps de leur vie, des métamorphoses plus ou moins complètes; mais jamais ils n'acquièrent, après leur sortie de l'œuf, de nouveaux segmens à leur corps." (*Résumé d'Entomologie*, p. 12.) All true insects, then, are *hexapod*, or *six-footed*; and the few genera now or lately classed with them, but of which the amount of feet is greater than six, belong to the Myriapoda—under which term the reader, in due time, will find their history and classification.

Definition. however, present fewer nervures, and are not reticulated, as in the preceding order. The mouth is furnished with mandibles and maxillæ, and the abdomen of the female is terminated either by an ovipositor or sting. Plates CCXLIV–V.

6. Lepidoptera (from λεπις, *a scale*, and πτερα, *wings*), containing all butterflies and moths, and generally characterized by the farinaceous or scaly aspect of the organs of flight, and the tubular or thread-like extension of the parts of the mouth. Plates CCXLVI–L.

7. Strepsiptera (from στρεψις, *a turning* or *twisting*, and πτερα, *wings*), including a few peculiar and parasitical species belonging to the genera stylops and xenos. This order corresponds to the *Rhipiptera* of Latreille, but we adopt Mr Kirby's denomination, as possessing a prior claim. Plate CCXLIV.

8. Diptera (from δις, *twice* or *double*, and πτερα, *wings*), including the house fly, and other two-winged kinds. The mouth is furnished with a proboscis, and there are two organs called poisers or balancers (*halteres*) placed behind the true wings, one on each side. Plate CCLI.

9. Suctoria (so designated from their sucking propensities) is constituted by the genus *Pulex* of Linnæus, and differs from the ensuing apterous orders in undergoing a regular metamorphosis, and possessing what some regard as the rudiments of elytra.[1] Plate CCLII. figures 13, 13 *a*, 14, 14 *a*, 14 *b*.

10. Thysanoura (probably from θιαζω, *to dance*, and ουρα, *tail*),[2] likewise an apterous order, including the *Podurœ* and other tribes. Plate CCLII. fig. 7, 8, 12, and 12 *a*.

11. Parasita (so named from their parasitical or adhesive propensities, because they dwell on the bodies of other animals) contains the genus *Pediculus* of Linnæus, and the *Nirmi* or bird-lice.[3] Plate CCLII. fig. 10, 11, and 11 *a*.

The study of the structure and habits of this numerous and diversified class of beings has long been a favourite occupation with men of science in all the continental countries of Europe, and has assumed of late years in the southern parts of our own island a character of considerable and increasing importance. Works have been recently published in this country which need fear no comparison with the most finished examples of pictorial representation; and when we consider how sparingly the subject of Entomology has been hitherto patronized by the public, we cannot sufficiently esteem the exertions of those who have thus devoted their time and talents to a pursuit which brings with it no other reward than the delight which every instructed mind necessarily draws from the contemplation of a favourite subject. Entomology, in truth, still stands in a difficult and somewhat dubious position, and presents itself to many under a far less inviting aspect than its beautiful sister-science of Botany. In connection with the latter study, the very mass of mankind, even the *profanum vulgus*, however ignorant of the technical details, have many early formed, and therefore pleasing associations. Every country-house has its flower parterres, and numerous cottages their glowing borders,—botanic gardens have been formed in the vicinity of most of the larger cities, while nursery grounds are frequent in the neighbourhood even of provincial towns,—to say nothing of the "flower enamelled meads" which each sparkling spring and gorgeous summer calls into fleeting but constantly renewed existence. In addition to the more attainable nature of this popular pursuit, some botanical knowledge is also regarded as a requisite branch of medical education; and although a tin box and a microscope do not constitute a man of science, still the subject derives advantage from that general though it may be superficial culture. But in Entomology every thing exists in a different order of relation. No "trivial fond regards" come in aid of the impaler of insects; and even the creatures themselves are too often regarded with such abhorrence, that one feels the more inclined to admire how those who endeavour to hand them down to an ungrateful posterity, should themselves be accused of cruelty. Definition.

The time however is surely gone by when an apologetical defence of the study might be required, or in which the works of Omnipotence were regarded as important in proportion either to their magnitude or immediate subservience to the human race;—and although we desire not to fall into an opposite error by maintaining the greater beauty and excellence of the more minutely elaborated designs of the Creator, we yet feel that they are fully more calculated to awaken our wonder and admiration. It would be easy to say that the richest and most elegant apparel which adorns the human race is the product of a caterpillar; that the blistering medicines so essential to the practice of the sanitory art are compounded from a beetle; that honey and wax, so valuable as articles of domestic economy, are derived from the glad labours of a hymenopterous fly; and that even that splendid and regal dye the "Tyrian purple" of ancient days, supposed to have been obtained from the *Purpura patula*, a shell-fish of the Mediterranean, is superseded by the tinctorial uses of the cochineal, a small and obscure insect, which nevertheless the skill of the chemist has rendered indispensable even to the garment of kings. But in truth far higher and more delightful results ensue from these researches, than can ever be named in the "cui bono" catalogue of a mere economist; for whatever tends to elevate the mind of youth above the grosser pleasures of sense, or even occasionally to disconnect our maturer years from the more turbulent occupations and harassing cares which life is heir to, assuredly carries along with it its own reward. We doubt not that a more sedulous and frequent attention to natural history would in active minds pre-occupy the place which is otherwise in after years too often devoted to more perilous courses. Even the pursuits of literature are often vague and objectless, and not unfrequently engender a sickly sentimentalism, or other morbid affection in nowise akin to genius. But the objects which attract the attention of the naturalist are not the melancholy creations of the human intellect, which present so often but a lurid brightness, or a dim eclipse, in which noble thoughts are obscured by the "darkening scales" of vice or folly. They are the work of Him who cannot err, and who has doubtless not only peopled the teeming earth and the translucent waters of the "great deep" with all their innumerable and varied wonders, for a wise and beneficent purpose, of which our instruction and amusement form at least a portion, but has, by the implantation of that strong instinctive love of nature which all ingenuous minds possess, demonstrated his desire that we should ennoble our humanity by magnifying his manifold works, the "wondrous works of him that is perfect in knowledge."

While the beautiful simplicity and regular order observable in those phenomena which proceed under the superintendence of omnipotence, commonly called the operations

[1] This suctorial order is named *Aphaniptera* by Mr Kirby, from αφανης, inconspicuous, because there is an appearance of something resembling elytra.

[2] In allusion, we presume, to the springing propensities of the insects of this order, which leap by means of a setiform process bent beneath the abdomen.

[3] Those who assume the occurrence of marked transformations as a basis for the grouping of the orders, will rank the first nine of the above as *Metabola*, or insects undergoing metamorphosis, and the last two as *Ametabola*, or insects undergoing no metamorphosis.

Definition. of nature, are well adapted to the comprehension of understandings laying no claim to the highest order, the more complex relations of the subject present a vast field for speculative or theoretical exercise, sufficient to occupy the faculties of the most powerful minds. It is thus that, in its totality, the subject of natural history holds out to each capacity the allurement of an occupation suited to every gradation of intellectual power; for while in its mysterious interconnection with other branches of natural science, as well as in its own peculiar complexities, it cannot be effectively grasped by mere human understanding, its manifold minor features may be scanned with intelligence by whoever desires so to do.

If indeed the value of a pursuit is to be estimated by the comparative ease with which it may be followed by persons of the most moderate fortunes, few can rank higher than Entomology. While the specimens sought for by the mineralogist and student of geology are frequently heavy and cumbrous, and not seldom extremely expensive, and while that sad representative of the beauties of the living Flora, called a *Hortus Siccus,* is but a frail and fleeting memorial of the "days of other years," presenting, even after a tedious and troublesome process of preservation (by courtesy so called), no trace of their original brightness, the most exquisite examples of entomological beauty, if not too roughly handled at the period of their capture, remain, with the most ordinary attention, for a lifetime in their pristine state,—and what that state actually is, all may satisfy themselves in the course even of the most superficial examination,—

> ....For nature here
> Wantons as in her prime, and plays at will
> Her virgin fancies.

Exceeding in amount of species all the other subjects of zoology,—unrivalled in the dazzling brilliancy of their colours, which combine the clearness and decision of tint possessed by flowers, with the exquisitely varied markings of the feathered race, and the metallic splendour of the mineral kingdom,—surpassed by no other work of creation in the wonderful structure of their parts, and certainly surpassing all in the adaptation of that structure to the perfect fulfilment of those natural though to us still mysterious instincts, which in every age have excited the admiration of mankind,—is it to be wondered at that the study of insects should occupy a prominent place in our pursuit of knowledge? Much more do we wonder that thousands of the best educated, and in other respects most enlightened minds, should still feel averse to a study which unfolds such a world of unseen wonders.

The subject, too, is literally inexhaustible; and while some who love to methodize, and thereby to circumscribe, the subjects of human knowledge, or who err in their estimate of the perceptive powers of the human mind as applied to other matters of enquiry, may be deterred by the vague boundaries of such a field, a greater number, and with more propriety it is hoped, may be induced to enter it, from the very consideration of such a rich and unreaped harvest. While a fragment of inert matter, which chemical analysis determines to differ in its constituent proportions from other fragments previously examined, is once in a lustre dignified by the name of a new *species,* and the name of a Haüy or a Dolomieu is bestowed on the unconscious mass,—and while, even in the richer domain of British botany, the student of that science, however much he may extend our knowledge of the localities of plants, labours with but a feeble chance of adding to the actual list even of indigenous species, and has probably no chance at all of ever refreshing his eyes with the sight of a plant which nobody ever saw before,—it is far otherwise with the innumerable tribes of insect life. The "gilded summer flies" are numerous as leaves in Vallumbrosa. No recess of the forest so obscure but there the "winged messengers" are seen to sport and play; and each summer sunbeam falls not alone on the dewy herbage of the open glades, but lights up the gorgeous hues of those bright creatures which a mystical philosophy has ennobled as the types of the disencumbered human soul, and which even the sombre Dante has named *angelical.* External Anatomy.

> Non v'accorgete voi, che noi siam vermi
> Nati a formar l'angelica farfalla.

Every pool of water is pregnant with life; each lonely moor or old deserted quarry, which scarcely "feels in its barrenness one touch of spring," is the chosen abode of thousands of living creatures, of small dimensions it is true, but of singular beauty both of form and structure, and often adorned with hues,

> Which make the rose's blush of beauty pale,
> And dim the rich geranium's scarlet blaze.

Even the pastoral melancholy of the green mountains is enlivened by the occurrence of many interesting species. One of the most beautiful of European coleopterous insects (*Carabus nitens*) occurs among the peat *hags,* and other places where heath and turf abound, and where its sparkling coat of gold and green, tinged with a brighter lustre than that of rubies, is singularly contrasted with the blackness of the soil in which it seems imbedded. The desolate and cloud-piercing summits of the highest hills produce several species, which are the more highly prized from their scarcity, and the difficulties with which they are obtained.[1]

We have alluded to the ease and *economy* with which the study of Entomology may be pursued, more especially when our attention is confined to the species of a district. Of course the collector of foreign insects labours under some disadvantage, from the more multifarious nature of his subjects, their larger size, higher price, and more scattered localities. But the home collector, especially of the Coleoptera, is more favourably situated.[2] The total Entomology of most districts may be amply illustrated within the bounds of a cabinet of a few feet square, and the most ordinary attention and regularity suffice for its preservation. Most districts produce species which are comparatively rare in other quarters, and thus by means of interchanges numerous additions may be made from time to time: so that with a moderate share of assiduity and perseverance, a large collection may be amassed with little or no pecuniary outlay. In these and many other pleasant particulars, on which we need not here dilate, Entomology possesses advantages over all the kindred branches of natural history. We shall now pass to a short exposition of some of the more characteristic features in the structure and functions of insects.

CHAPTER II.

THE EXTERNAL ANATOMY OF INSECTS.

Our knowledge of the manners of these creatures presents us with few general results, and this is scarcely to be won-

[1] The foregoing brief "defence of insects" coincides with that which, since the above was written, has appeared in our *Entomologia Edinensis.*

[2] A glazed frame or drawer, lined with cork, and capable of containing many hundred species, may be made for a few shillings.

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dered at, when we consider with how small a number we have any accurate acquaintance. It may even be doubted whether we are completely informed of the history of any one species within the entire range of Entomology. Of some we know the perfect state, but have never seen the larva; of others the larvæ are well known, but the perfect insect remains in obscurity, so that when we consider the numerous changes which these creatures undergo, from their first hatching to their final metamorphosis, we need scarcely wonder that even the most familiar species present points in their history, which it is by no means easy to unravel.

It is otherwise however with the classification of insects, which, depending mainly on an attentive examination of external characters, is so far independent alike of anatomical investigation and the study of manners, although these, when ascertained, form of course the truest test by which to appreciate the difference between a natural and an artificial system.

The period is comparatively recent during which the internal structure of insects began to be regarded as a subject of interest. Their external characters were the first to attract attention; and as a communicable knowledge of these was necessary for all the practical purposes of classification, as well as to establish the means of mutual understanding among naturalists, it is well that that branch has been rendered so complete and satisfactory. In former times, whatever facts of interest might have been ascertained, were too often but of slight avail, in consequence of our vague knowledge of the species to which they applied. But the most ordinary attention on the part of the anatomist, to the systematic works of modern times, will now suffice to inform him of the place which his subject occupies in the scale of nature; and hence the importance, not seldom overlooked by the physiologist, of even the minutest external characters, when accurately ascertained and clearly described. It has indeed been stated as a truism, that whoever attempts to deduce the real affinities of the animal kingdom from a consideration of the external characters alone, will in most cases mislead both himself and others.[1] But it must also be admitted, that comparative anatomists have too frequently an idea that nothing is or can be of importance which extends beyond the sphere of their own exertions. They forget that the general form and covering, and, in short, the whole of the external characters, however they may labour under the misfortune of being obvious to a common observer, are just as much a part of an animal's organic constitution, as the nerves, viscera, muscles, blood-vessels, and bones, or whatever else is most mysterious and recondite; and that, in fact, without a precise knowledge of the former, the information conveyed by the latter would be uncertain, or of no avail. The chief advantage of the internal structure is, that it is less liable to variation from the influence of local or accidental circumstances: its chief disadvantage results from the difficulty of its ascertainment, and the contrariety of opinion which exists among physiologists regarding the uses of the organs, even after their conformation has been ascertained. A mere knowledge of external character is perhaps nearly as useful as an acquaintance, however intimate, with anatomical structure, when nothing is either known or sought for respecting the external appearance, as a necessary guide to the higher knowledge of animal instincts and modes of life, the uses of living creatures in the general economy of nature, their exquisite adaptation to the circumstances under which they are placed, their distribution over the earth's surface, and other points of philosophical investigation. The mere anatomist may smile at the mere collector of shells and butterflies; and with just as much propriety may the mere naturalist or virtuoso smile in return at him who, knowing, or supposing that he knows, every convolution of a viscus, or ramification of an artery, is yet unable to recognise, amid the perplexingly multiplied varieties which may be presented to him, the precise animal which has been the subject of so much anxious and careful investigation. But when anatomy and natural history go hand in hand, the obscure labyrinth of nature, so far as human capacity can penetrate, receives its noblest illumination.

Notwithstanding the meritorious labours of Swammerdam, Malpighi, Réaumur, and Lyonnet, who were the first greatly to signalise themselves in the difficult field of insect anatomy; in spite of the more recent and scarcely less successful exertions of Cuvier, Comparetti, Ramdohr, Treviranus, Gaede, Sprengel, Savigny, Marcel de Serres, Geoffroy St Hilaire, Carus, Meckel, Audouin, and Dufour (to make no mention of many others who yet deserve to be held in remembrance),—such is the immense extent and variety of this wonderful class of beings, that we fall infinitely short of possessing any thing like a general or completed knowledge of their structure. In this paucity of well-established facts under which we labour, it would indeed be unphilosophical to attempt the induction of general rules; and all that we shall here attempt shall be to record such observations as seem likely to bear substantially upon the subject, and to have formed an actual advance in our knowledge of the anatomy and physiology of insects.

The study of the interior structure of these creatures does not at first sight hold out the promise of much that is either interesting or useful. The enormous distance which seems to separate all invertebrated animals from man, and even from the lower mammiferous and other vertebrated tribes, has induced the belief that no practical results can ever spring from such a source. But the philosophical observer, who knows how important is frequently the connection between the greatest and the least of things, and how, like the thread of Ariadne, the tracing of a slender chain may lead to unforeseen conclusions of the highest value, will not despise the lights which a better knowledge even of insect anatomy may be one day destined to throw upon some of the many still obscure points in the physiology of man. The observations of M. Dufour and others have already shown us what an admirable simplicity presides in these despised tribes over the exercise of those most important functions, which in red-blooded animals require such a complicated organic structure as to be almost incomprehensible. But as we descend in the scale of nature, we see more clearly the distinction between what is necessary, or merely accessory or superfluous, and thus by degrees we may attain to a knowledge of the essential characters of things.

Even in its more superficial bearings on natural history, the dissection of insects is necessary to ascertain several disputed points regarding the sexual distinctions of species, and to verify our views of the structure of the organs of the mouth, the antennæ, tarsi, and other external parts, on which our establishment of tribes and genera mainly depends. When it is desired to dissect an insect, it ought to be placed on a piece of cork, immersed in pure water; and the various parts, as they float in the liquid, may be fixed in their most appropriate position by means of needles. With a view to prevent deception from any alteration in the relative position of the internal organs, it is desirable

[1] Wilson's *Illustrations of Zoology*, vol. i. pref. p. 4.

to fix the insect in its natural horizontal posture, and to commence the dissection from the dorsal region downwards.

The following observations on the dissection of the minuter animals may be of service to the student. "The first thing that I have to observe is, that all dissections of small and soft objects, *e. g.* worms, zoophytes, insects, mollusca, &c. where it is desirable to obtain even tolerably accurate results, should be performed *under water*, by which the parts are kept floating and separated from each other, and consequently present themselves more distinctly. A very simple contrivance for investigations of this kind may be prepared in the following manner: A mass of tough wax (not too soft) is to be laid upon one or more porcelain saucers or capsules of different sizes, which are then to be put in a warm place until the wax melts so as to cover the surface evenly to the depth of a half or a third of an inch. If the object to be examined be laid upon this surface, it may be fixed by needles in any position that is wished; and, when covered with clear water, developed and dissected by means of suitable instruments. Of these, the best are very delicate forceps; pointed, well made, sharp-cutting scissars; and small knives like cataract needles, some round, others with cutting edges, and fixed in slender wooden handles. For separating parts I have also employed small horn probes and fine brushes; whilst for examining them a good magnifying glass is frequently indispensable. If it is wished to preserve a preparation thus made, wax coloured at pleasure, as for the purpose of injections, is to be formed into little tablets about a quarter of an inch thick; one of them is then to be placed upon the saucer or capsule containing the preparation; the latter may then be transferred to it, arranged suitably upon it, fixed there by means of short needles, and both together placed in alcohol. Nor must I forget to mention, that the examination of very delicate organizations may frequently be conducted with greater facility and accuracy, if the object be previously allowed to remain some time in spirit, and thereby to become harder and contracted. This applies particularly to the dissection of nervous organs, and to the examination of very small embryos, of mollusca, and worms. There are various ways of destroying worms, insects, &c. for the purpose of dissecting, without injuring their organization. Mollusca, snails for example, as Swammerdam has remarked, are to be allowed to die in water, because by that means their body swells, and all the parts become more distinctly visible; they may afterwards be kept in spirit (though not too long) for dissection. Worms, the larger zoophytes (for the smaller must be examined whilst alive), caterpillars, &c. are best destroyed by means of spirit; insects, on the contrary, by being dipped rapidly in boiling water, or in oil of turpentine."[1]

SECT. I.—THE EXTERNAL COVERING OF INSECTS.

Our knowledge of the structure and anatomy of this class may be said to be still in its infancy; for although many important facts have been legitimately generalized, we are still in ignorance of the formation of a thousand species for every one which has been examined. As the harder parts of insects, to which the muscles are attached, are superficial, the class has been described as bearing their skeletons externally; and a transcendental anatomy has not scrupled to determine the exact analogy which each portion of their covering bears to the bony frame-work of the vertebrated tribes. This comparison has been instituted by M. Geoffroy St Hilaire, an eminent physiological naturalist of France, who maintains, with many of his countrymen, that all animals are vertebrated. The doctrine, whatever may be its other merits, is not entitled to the credit of novelty, as an English writer of the name of Willis had, so far back as the year 1692, published his opinion that the external envelope of the body of insects represented the internal articulated column of the vertebrated tribes. M. de Blainville, on the other hand, regards the corneous covering of insects rather as analogous to the skin or cutaneous system of the higher classes.

The hardness of the calcareous or horny envelope of the greater number of insects is owing, in Latreille's opinion, to the consistence of the excretion interposed between the dermis and the epidermis, or what is termed in man the *mucous tissue.* This excretion also contains the brilliant and varied colours which add so greatly to the beauty of the class.[2] According to M. Odier, who has attentively examined the composition of the harder parts of insects, the substance of this envelope is of a peculiar nature. He has named it *chitine.* He observes that the phosphate of lime forms the great proportion of all the salts contained in the teguments of insects, while that ingredient is but trifling in the covering of the Crustacea, although the latter abounds in the carbonate, which is not found in the other class.[3] The facts stated by him militate against the analogies attempted to be established on the subject; and the observations of M. Straus go far to demonstrate that those teguments do not form a true skeleton, but really represent the skin of the vertebrated classes. When we use the word skeleton, then, in relation to insects, the reader will understand its application merely to the external covering.

On analysing the elytra of the cockchafer, M. Odier ascertained the existence, 1*st,* of albumen; 2*d,* of an extractive matter, soluble in water; 3*d,* of a brown-coloured animal substance, soluble in potass and insoluble in alcohol; 4*th,* of a coloured oil, soluble in alcohol; 5*th,* of three salts, viz. subcarbonate of potass, phosphate of lime, and phosphate of iron; 6*th,* of a peculiar substance which constitutes a fourth part in weight of the elytron. Albumen is so generally distributed among the animal organs that its presence was to be expected. But the oil is deserving of further experimental observation. Robiquet found it of a green colour in cantharides; while, according to Odier, it is brown in the cockchafer, and red in a species of crioceris. Now as each of these insects is itself of a corresponding hue, it is natural to suppose that the oil is the colouring matter. The peculiar substance which forms so large a proportion of the elytra is named *chitine* by M. Odier. If we plunge a coleopterous insect into a solution of potassium, and keep up a pretty high temperature, we shall observe that the so-called skeleton neither dissolves nor changes its form; it merely becomes discoloured during the operation, while all the viscera and interior muscles disappear; and whatever remains of the insect is *chitine.* This substance exists in the whole of the envelope, and is also found to occur in the more solid covering of the Crustacea.

If however we compare the preceding results with those obtained by M. Chevreul in the course of his experiments on crustaceous animals, we shall perceive some remarkable distinctions in the constitution of their harder parts. The presence of subcarbonate of potass is a striking character among insects. It does not occur in the class Crustacea. The phosphate of lime, a sparing ingredient among the latter,

[1] Carus's *Introduction to Comparative Anatomy,* translated by Gore, vol. ii. p. 389.
[2] *Règne Animal,* t. iv. p. 2.
[3] *Mem. de la Soc. d'Hist. Nat.* t. i. p. 29.

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forms a preponderating part of the salts in the envelope of insects, while the carbonate of lime is absent, although it forms the base of the carapace or covering of crabs and lobsters. It has been stated as a regulating law in animal chemistry, that the bones of the higher orders have more of the phosphate and less of the carbonate of lime in their composition, while the proportions were reversed among the inferior tribes. But the observations of M. Odier show the inadequacy of chemical character to serve as a basis on which to found our analogies of organization; for if strictly applied to insects, that class must be removed from the place which they now occupy in our system, and be combined with others of a higher nature, with which in truth they have no connection.

The harder and more solid parts of insects are certainly to them what the internal skeleton is to the vertebrated tribes. They form the support and frame-work of the body. It is on this account that the term *skeleton*, though not strictly applicable, has been used, both in ancient and modern times, to designate the *corneous external system* of these creatures. This comparatively solid system is itself formed by the union of many parts, which however have received no general name; so that, while in discussing the vertebrated tribes we merely say that their skeleton is formed of bone, all that we advance in regard to insects is, that it is composed of pieces. In the higher tribes each individual bone is well known by its own distinctive name; but the insect tribes in that respect have been but obscurely defined. Guided by the light of human anatomy, observers have sought to discover in insects all those parts to which they could apply previously established names; but analogies based upon mere appearance are incapable of great or useful extension; and insects would certainly have been better known had they been studied in the first place individually, and no far-fetched comparisons instituted till after a more ample knowledge of actual organization. But instead of this, the best determined functions of the superior animals have been assumed as points of departure, and all the parts of insects which *seemed* to fulfil the same purposes have been determinately regarded as analogous. Now it is quite admissible to say, that in insects, as among the vertebrated tribes, there is progression, vision, manducation, &c. because these are the attributes, more or less general, of all living beings; but it has not always been demonstrated that particular and more special functions are always performed by the same or apparently corresponding parts. M. Dufour, however, has announced the following results in relation to the articulated animals themselves: 1*st*, that the skeleton of the Crustacea and Arachnides (two important classes already described in this work) does not differ from that of insects except by the mode of growth of the rings of which it is composed; 2*d*, that those two classes of animals and insects themselves do not differ among each other, but by the greater or less extent in the development of the parts of which they are composed.

The same may be asserted in regard to the disparities observable between the different conditions of insects in the larva, the chrysalis, and the perfect state. The various forms under which the same species is exhibited, and the singular and sometimes sudden transformations to which it is subjected, are found to result, when analysed, from the growth of parts. This has been demonstrated by the writings of Swammerdam and other modern writers on the anatomy of caterpillars, as well as by the beautiful and more recent observations of Savigny on the mouths of Lepidoptera in the perfect state, compared with the same parts in their earliest condition.[1] The observation is particularly applicable to the solid parts of insects. In the larva each segment exists under a nearly uniform development, while in the perfect state several of these segments have acquired a prodigious increase. This is the cause of the vast difference in their exterior envelope at different periods of their existence. The nymph or chrysalis is in the intermediate condition, and is formed, like the larva, of simple rings, which, however, no longer exhibit an equal degree of uniformity. But the perfect insect is the final term of transformation. Considered in a general way, its covering does not essentially differ from that of the larva; but the three segments next the head have acquired a great increase of bulk, to enable them to support the appendages of legs and wings, which were merely rudimentary, or scarcely existent, in its first condition; and the distinction of head, thorax, and abdomen becoming strongly visible, the entire aspect of the insect has undergone a change.

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It is highly interesting to observe the influence which the decrease or development of one portion of structure exercises upon another; in other words, the constant and intimate relation of the proportion of parts. The maximum of increase in the metathorax is always in relation to the rudimentary state of the mesothorax, while, on the contrary, the development of the latter produces or accompanies the decrease of the former. Thus also the parts of the mouth, as demonstrated by M. Savigny, are sometimes free, and capable of varied movement, for the purposes of mastication; while in several tribes they are brought close together, lengthened, and as it were amalgamated in the form of trunk or sucker; and so the segments of the thorax, in the different orders, more or less disunited among themselves, support the wings, the balancers, the elytra, according to the various kinds. From these and similar considerations have been deduced the conclusion that the increase of one portion exercises over the neighbouring portions a peculiar influence, which explains whatever differences may be remarked in the individuals of each order, family, and genus. And this general consequence, which results from numerous observations, necessarily includes and accounts for that incoherent series of anomalies so puzzling to the superficial inquirer, but which are only regarded as such, because the labourers in the field of anatomy have but seldom taken into their consideration the totality of the articulated animals, and have more seldom still thought fit to occupy themselves in a careful comparative analysis of the parts which enter into the composition of the external skeleton of these despised tribes.

We shall here briefly consider the essential characters of the so-called skeleton among the articulated tribes. It is composed of segments, which are themselves formed by a determinate number of pieces; but their most obvious character is, that they are provided with a pair of feet, and with two openings to the respiratory organs. But along with such segments as present these parts, we may usually observe many others which are not so provided, or at least in which the feet are wanting; and they may either differ in their size and proportions, or closely resemble each other in those respects. In the latter case, the most simple form is exhibited; and if we ascertain the composition of a single segment, and their amount, we have a knowledge of the entire animal. This simplicity of form, however, is not often observable; for it more frequently happens that the same individual presents great disparity in the size and composition of its segments, and in the appendages with which they are furnished.

The Scolopendræ (belonging to the class MYRIAPODA) ex-

[1] *Mémoires sur les Animaux sans Vertèbres.*

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hibit, according to M. Dufour, one of the most simple forms of the articulated classes, in as far as they present the greatest uniformity of character in the parts of which they are composed. Even in them, however, we may observe, at the anterior portion, some pairs of feet, which are rudimentary, and crowded together towards the head; so that it would be possible to figure an animal still more uniformly composed, by supposing that the feet thus thrown together had been developed uniformly with the appendages of the ensuing segments. We should then have had to recognise merely a head, and a certain number of rings, all of a like nature. But it might be possible still further to reduce and simplify the proposition, by regarding the head itself as an assemblage or union of segments, bearing appendages merely analogous to the feet. Thus, to realize the supposition of a skeleton uniformly constructed throughout all its parts, nothing more would be necessary than to give to the segments of the head a development equal to that of the others, and to restore to its appendages (the feet) their essential usage, that of locomotion, instead of the secondary usage to which they had been subjected. This view has been presented in order to exhibit what has been regarded as the fundamental plan of insect formation; for it is in truth the corresponding or unequal increase of the segments, the union or division of the pieces of which they are composed, the maximum of development in some, the rudimentary condition of others, that form the agreements or differences of character in the entire series of articulated animals.[1] If the development is uniform, or nearly so, in each segment, we have the condition of the *Annelides*, of *worms*, and of the *larvæ* of insects. If, on the contrary, this equilibrium is destroyed, and the maximum of increase takes place in the first, second, and third segments ensuing the head, we have the form and character of a *perfect insect;* if the change is still greater, we reach the *Arachnides;* if greater still, the *decapodous Crustacea.*

The importance of studying the skeleton of insects is greater than even among the higher classes, because, being essential, it forms a genuine basis, and being at the same time external, it offers to the eye of the zoologist a ready mode of determination.

While engaged in the consideration of the various organs of insects, a numerous list of disparities in structure might no doubt be collected, and the term *anomaly*, according to its frequent but by no means philosophical application, brought into constant use. That fatal word, however, has been too often substituted in place of an explicit interpretation of phenomena not in any way difficult of solution, certain general principles being kept in view. Of these, one of the most importance is, that all the differences exhibited by insects, and all the so-called anomalous organs which they present, are the result of a greater or less development of certain parts existing generally throughout the entire class.[2] The contrariety of opinion among naturalists regarding the existence or proportion of certain parts of structure, has arisen partly from a discordance in the use of terms, and partly from the organs themselves not being submitted to a careful analytical investigation. It is thus, for example, that the names of *sternum* and *scutellum*, in place of being bestowed on portions of which the contours have been precisely determined, have only been applied when these portions happened to exhibit certain accidental and conventional characters. By this means we read in almost every page of classification, that one insect possesses a scutellum and that another does not; or that a particular genus is characterized by its existence, and another by its absence; while the fact is, that these parts exist in all insects, although the names in their usual application have been bestowed only upon peculiar and not very important variations in the *form.*

SECT. II.—THE EXTERNAL CHARACTERS OF THE PRINCIPAL SEGMENTS OF AN INSECT'S BODY, VIZ. THE HEAD, THORAX, AND ABDOMEN.

The form of the external covering of insects, even of the same species, differs greatly according to the existing condition of the individual. The segments of which the bodies of larvæ are composed are generally of a uniform size when compared with each other, and the singular phenomena presented by metamorphosis consist chiefly in the greater development assumed by certain segments than by others. The nymph (called chrysalis among the Lepidoptera) exhibits the intermediate or transitionary state. Its segments are unequally developed, and this inequality is greatly increased on the assumption of the final state, in which certain segments are prodigiously enlarged, while others suffer a corresponding diminution. In the imago, or complete condition, the three segments next the head undergo the most notable alteration; for, besides their increase of bulk, they become furnished with wings and articulated legs, which had previously existed in a very rudimentary condition. In that state also the relative proportions of the segments are so changed that the identity of several becomes difficult to recognise, and the most obvious divisions henceforth consist of *head*, *thorax*, and *abdomen.* These parts are severally characterized by peculiar attributes, the nature of which we shall now endeavour to explain.

The *head* is by far the most complicated portion, and it is necessary that its structure should be well understood, as it furnishes the most important characters on which modern genera are founded or made known. The parts most deserving of attention are the *mouth*, *antennæ*, and *eyes.*

The organs of the mouth present in their different combinations a great variety of form among the articulated classes. In relation to all such animals as are provided with a head, more particularly the vertebrated tribes, the term mouth is never of ambiguous application, but refers to those parts which are placed exteriorly at the entrance of the intestinal canal, and effect the process of mastication; but in regard to the acephalous or nearly headless tribes, such as annelides, worms, and the radiated animals, its application is less definite and precise. Among the great series of living beings included by Linnæus in the class of insects, all of which are furnished with a head, the parts of the mouth are no longer doubtful. It has been remarked, however, that the sucker of the larvæ in the last family of the dipterous order being entirely interior when not in use, presents a singular approximation in that particular to the intestinal worms.

It will be readily conceived that the mouth of insects must be adapted to the particular manners of life peculiar to each natural group, and must therefore vary in accordance with their instinctive habits. It was thus that even the earliest naturalists perceived and expressed the distinction between insects provided with teeth or cutting jaws, and those furnished with trunks or suckers. The use of the microscope in modern times, and the deep desire which prevailed towards the conclusion of the seventeenth and commencement of the eighteenth centuries, to illustrate the mysteries of animal organization, produced much more detailed and exact accounts of the parts of the mouth in insects than were previously possessed. The works of Leeuwen-

[1] *Ann. des Sciences Nat.* t. i. p. 115.

[2] *Ibid.* p. 102.

hoeck, Swammerdam, and Réaumur are mines of information; while Scopoli and Degeer still further generalized the observations of these illustrious naturalists. Scopoli, we believe, was the first to apply the knowledge of these parts in characterizing the genera of the hymenopterous and dipterous orders; but it is to a celebrated disciple of Linnæus, John Christian Fabricius, that we owe the first general theory of the parts of manducation, and its application to entomology in general.

The alimentary substances sought for by insects are either comparatively hard and solid, or of a more soft and fluid nature. Thence we find upon examination numerous tribes of insects provided with a mouth so constructed as to tear and masticate the substances on which it is designed to act; while many others are characterized by a tube-like mouth, or one resembling a delicate tongue extended when in action, and spirally rolled upon itself when in repose. Hence the great primary distinctions among the orders of insects, and their recognised division into masticators (*mandibulata*) and suckers (*haustellata*), the former living on solid substances, the latter on such as are fluid. Whatever may be the structure of the mouth in insects, it is to one or other of those types of form that each must be referred. We are indebted to the beautiful researches of Savigny (1814) for the first accurate analysis and elucidation of these parts, and of their relationship throughout the articulated tribes. Latreille, however, had previously instituted a slighter comparison between the mouths of the suctorial and mandibulated tribes, as Lamarck has admitted in his report on Savigny's work.

Savigny divides insects formerly so named into two groups, the *hexapodes*, or such as have six feet, and the *apiropodes*, or such as possess a greater number. The mouth of the latter forms two proper types distinct from those of the former; but it is with the polymorphous hexapodes, or such as undergo transformations, that is, insects properly so called, that we are now concerned. We shall first consider the parts of the mouth in the masticating tribes. They are essentially as follows: The *labrum*, the *mandibles*, the *maxillæ*, the *palpi*, the *labium*, and the *mentum*, the two latter, according to the views of different observers, sometimes passing under one and the same name. The reader may here consult Pl. CCXXXIII. fig. 1, *a*, *b*, *c*, *d*.[1]

The *labrum* or upper lip (fig. 1, *a*) is a flattened somewhat deflexed portion, consisting of a single piece,[2] placed on the upper side of or above the mouth, and capable of moving upwards and downwards, or vertically. It is variable in form, but is usually somewhat square, often wider than long, and frequently notched or bifid. It is of a horny consistence, sometimes coriaceous, or even approaching to what may be named membranous in certain tribes, and is attached to the anterior portion of the head by a very short articulation.

The mandibles or upper jaws (*mandibulæ*, fig. 1, *bb*) are two strong horny pieces, generally of a triangular form, more or less curved, convex externally, concave on their inner surfaces, and frequently toothed or serrated on their interior edge. They are placed on each side of the mouth by insertion on the sides of the head, immediately beneath the labrum or upper lip, which usually covers their base. They are each composed of a single piece of a hard consistence, and may be said to correspond to the jaws of the vertebrated tribes, the process of mastication being principally performed by them. They differ, however, in this respect, that their motion, instead of being vertical, is horizontal, or from within outwards, and *vice versa*. They vary greatly both in their actual size and relative dimensions, being small and slender in the glow-worm (*Lampyris*), and very large, projecting, and antler-like in the stag beetle (*Lucanus cervus*), the species which we have selected for our engraved illustration. These internal surfaces are frequently parallel, but their dentations are not always the same in each, the projections of the one being however frequently so arranged as to enter the concavities of the other in order to admit of their closer union. But this is not seldom prevented by the curvature of the tips; and in several instances, where the mouth is wide, and the mandibles rather remote from each other at the base, the blades cross each other a little beyond the centre. The dentations of the mandibles, though sometimes called teeth, are merely projecting parts, although in the orthopterous tribes a coriaceous lamina seems in some respect to distinguish them from the body of the mandible to which they are attached, thus exhibiting an approach to that mode of fixture called *gomphosis*, in which one bone is fixed within another, as in the teeth of the higher tribes. The mandibles are more variable in their forms than the maxillæ, and may occasionally be observed to differ (as in the genus *Lucanus*) even in the sexes of the same species.

Immediately beneath the mandibles are situated the *maxillæ* or under jaws (fig. 1, *cc*), which are likewise placed on each side of the mouth, and take their origin from the inferior and internal part of that cavity, near the origin of the under lip. Like that of the preceding parts, their action is horizontal, but their texture is less rigid, approaching to membranous, their colour usually paler, and their internal edges toothed, or finely fringed with hairs. The different portions of the maxillæ have received different names, such as the *cardo* or hinge, the *stipes* or stalk, and the *lobus* or lobe (one or more) which forms the terminal portion. The last named is the most important portion, as it acts upon the food when preparing for deglutition, and when armed with teeth its substance is as hard as that of the mandibles. "This part," says Mr Kirby, "is either simple, consisting only of *one* lobe, as you will find to be the case with the *Hymenoptera*, *Dynastidæ*, *Nemognatha*, and several other beetles; or it is compound, consisting of *two* lobes. In the former case, the lobe is sometimes very long, as in the bee tribes, and at others very short, as in hister, &c. The bilobed maxillæ present several different types of form. Nearest to those with one lobe are those whose lower lobe is attached longitudinally to the inner side of the stalk of the organ, above which it scarcely rises. Of this description is the maxilla in the common dung beetle (*Geotrupes stercorarius*), and rove beetle (*Staphylinus olens*). Another kind of formation is where the lower lobe is only a little shorter than the upper; this occurs in a kind of chafer (*Macraspis tetradactyla*, Macleay). A third is where the upper lobe covers the lower as a shield; as you will find in the *Orthoptera* order, and the *Libellulina*, and almost in *Meloe*. A fourth form is where the upper lobe somewhat resembles the galeate maxilla just named, but consists of two joints. This exists in *Staphylinidæ*, &c. The last kind I shall notice is when the upper lobe not only consists of two joints, but is cylindrical, and assumes the aspect of a feeler or palpus. This is the common character of almost all the predaceous beetles (*Entomophagi*, Latr.)."[3] This lobe, which has been usually regarded as an

[1] *a* is the labrum, surmounted by its broad nasus; *b* the mandibulæ; *c* the maxillæ, with their jointed palpi; *d* the bifid labium, with its two palpi and broad basal portion or mentum.

[2] In the female of a small bee of the genus *Halictus* it is said to be furnished with a slender appendage.

[3] *Introduc. to Entom.* vol. iv. p. 442.

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additional palpus or feeler, is strictly analogous, in Mr Kirby's opinion, to the upper lobe in other insects, and he thinks it ought rather to be called a palpiform lobe than a *palpus*. When there are two lobes, the upper one is most commonly the longer; but in many species of the tribe last alluded to, the lower equals or even exceeds the upper in length.[1]

Most of the predaceous beetles have the inner lobe of the maxillæ armed with a terminal claw, which, among the Cicindelidæ, is articulated and moveable, but fixed in the other carabideous kinds. The maxillæ are chiefly serviceable in holding the food, and preventing its falling from the mouth during the action of the mandibles, although in certain cases they no doubt also act their part in comminution. They are more fixed in their forms than the mandibles, and are of more essential service to the naturalist for the purposes of classification. Fabricius, indeed, has deduced the principal diagnostic of ten out of the thirteen orders (or classes, as he terms them), of which his system is composed, from these important parts.

We shall now briefly notice certain appendages of the maxillæ, the existence of which forms another distinction between them and the mandibles or upper jaws, which are never so provided. Towards the middle of the outer edge of the maxillæ are attached two slender articulated filiform processes, known under the name of palpi (see the figure above referred to); the longer pair being the external, the others the internal palpi. Both are called *maxillary*, to distinguish them from the *labial* palpi, afterwards mentioned. According to the view expressed by Mr Kirby in the preceding quotation, the reader will perceive that each maxilla may be regarded as properly possessing only one palpus, although in certain tribes the upper lobe being jointed and *palpiform*, has occasioned its being regarded as one of these organs. The palpi are distinctly articulated, or composed of several jointed parts, and are capable of rapid and extended motion. They derive their name from a Greek word, which signifies to feel, and are supposed to constitute one of the principal organs of touch. Their uses, however, in the insect economy have been variously interpreted. Bonsdorf regarded them as the organs of smell; while Knock, agreeing in that opinion so far as regards the *maxillary* palpi, conceives that those of the *labium* exercise the faculty of *taste*. Cuvier and Kirby favour touch as their true function, and this view is confirmed by the constant use which numerous species make of these organs while walking, by applying them perpetually to the surface of whatever objects they pass over. That they perform that function is rendered extremely probable by their structure, which is beautifully adapted, by its peculiar pliancy, to the examination of the substances with which they come in contact. They are in some respects analogous to the articulated extremities which form the principal seat of the sense of touch in vertebrated animals. It has also been noticed that several aquatic beetles, while swimming, bend back their antennæ, and stretch forward their palpi, as if to explore their way through the ambiguous and weedy waters. As accessory to the maxillæ, they are no doubt also employed in the selection of the most suitable alimentary portions of whatever substances have been previously seized upon by the more powerful parts of the mouth. In many insects there is only a single palpus to each of the maxillæ.

As the mouth is covered above by the *labrum*, or upper lip, so it is closed below by the under lip, or *labium* (fig. 1, *d*). The latter differs in its structure from the labrum, being more complex than that organ, and composed as it were of two portions joined together. It varies in its form, is usually notched in front, and frequently furnished with a triangular tooth in the centre, which is sometimes bifid. Mr Kirby defines the labium as a moveable organ, often biarticulate, which, terminating the surface anteriorly, covers the mouth from beneath, and is situate between the maxillæ. It includes the mentum and labial palpi. The more uncovered portion of the labium, or that which projects from the basal portion, is now named *languette* or *ligula* by Latreille, in consonance with the nomenclature of Fabricius. The *mentum*, or chin, is the lower joint of the labium when the latter is jointed; in other cases its base.

Some contrariety of opinion seems to exist in the nomenclature of these parts. Mr Macleay bestows the name of *mentum* on the middle piece of the lower apparatus of the mouth. Its anterior portion, to which the palpi are so frequently attached, he calls the *labium*, while the basal part of the mentum is designated the *stipes*. In this view the labium of Macleay corresponds to the *ligula*, or rather tongue, of Kirby, while the mentum of the latter is analogous to the stipes of the former; for it appears that the term mentum is only applied by the author of the *Introduction to Entomology* to the lower division of the labium, when that organ (as in *Hydrous piceus*) appears to consist of two joints or pieces. When there is no apparent division, or the only separation consists in a transverse elevated line (as in some lamellicorn beetles), or an obtuse angle formed by the meeting of the two parts, then the entire piece (the *mentum* merging in it) is regarded by Mr Kirby as the *labium*.

Among the greater proportion of masticating insects there is placed anteriorly at each side of the ligula a small supporting piece or article, which takes its rise a little above the pharynx, and is terminated by a projecting appendage. These parts were named *paraglossæ* by Illiger; and M. Latreille regards them as the true representatives of the tongue of the higher tribes. The labial palpi (Fig. 1, *d*), are inserted on each side of the ligula, and are usually longer than the internal and shorter than the external maxillary palpi. These palpi have never more than four articulations, in which they also differ from the external maxillary, which range from four to six. They are called labial palpi, because in many cases they derive their origin from the labium strictly so called; but in reference to Mr Kirby's nomenclature of the parts, they might with equal propriety be denominated lingual palpi, since they not unfrequently emerge from what that excellent observer considers as the tongue. Among the predaceous Coleoptera, indeed, their source seems common to both these parts, as their base on its upper side is attached to the labium, on its under to the ligula or tongue.

In some insects, such as the Orthoptera and dragon-flies, the membranous portion with which the anterior or internal face of the ligula is furnished, is thick and dilated near the centre, in the form of a little tongue, and is often divided near the middle by a groove. This portion, in the opinion of Latreille, probably occupies the place of the *paraglossæ;* for these latter, in the instances referred to, are wanting, or not to be recognised.

These are the principal parts of the mouth among the masticating insects. At the anterior root of the ligula, and a little lower than the middle of the interior space which intervenes between the mandibles, is placed the *pharynx*. In many Hymenoptera this orifice of the œsophagus opens and shuts by means of an appendage, previously noticed by Réaumur in humble bees, and taken by Latreille for the labrum, in his observations on the structure of wasps. Savigny has since paid particular attention

[1] *Introduc. to Entom.* vol. iv. p. 442.

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to it, and has named it the *epipharynx* or *epiglossa*. Latreille conceives it would be more simple to call it the *sublabrum*, because it is inserted beneath the anterior and superior margin of the head, immediately after the origin of the labrum. It is formed of two flattened portions, entirely or in great part membranous, applied the one upon the other, and of a triangular form. The upper portion is the most advanced. This epipharynx, instead of being peculiar, as some have supposed, to the Hymenoptera, may be safely regarded as existing in the other masticating insects, particularly the Coleoptera, among which it seems represented under a modified form of structure by the membrane which clothes the corresponding portion of the head.

Although the hymenopterous tribes differ from the other mandibulated orders, by the prolongation of the maxillæ and labium, and the valvular aspect of the former, yet the parts of the mouth do not present any essential distinction. A remarkable characteristic of these orders, however, consists, as Savigny informs us, in the absence of the mentum properly so called. They also exhibit this disagreement from the other masticators, in as far as their maxillæ embracing longitudinally the sides of the labium, these parts unite together so as to form a tubular body or trunk (*promuscis*), serving for suction. As their aliments consist of softish substances, or of nectarous juices, which, passing between the maxillæ and the labium, by means of the successive pressure of the former parts upon the latter, eventually arrive at the pharynx, they may in truth be regarded as semi-suctorial. Even the Rhinchophori among the Coleoptera, and the Panorpati in the neuropterous order, are furnished with an apparent trunk or prolongation of the muzzle (*prorostrum*); but that peculiarity is nothing more than an extension of the anterior portion of the head; and the organs of manducation, placed at its extremity, though of diminished size, in no way differ in structure from those of the other groups of their respective orders. We may add, that the labium or lower lip in the hymenopterous tribes is generally moveable at its base, as may be observed in the corresponding tribes of the suctorial insects.

In the suctorial or haustellated orders, properly so called, the organs of the mouth appear at first sight to differ entirely from those above described. The parts which are regarded as analogous to the maxillæ, and frequently even those which represent the mandibles, are fixed and immoveable, either entirely so, or towards their base, and (in regard to the maxillæ) as far as the origin of the palpi. When the terminal portion is moveable, it is long, narrow, linear, sometimes in the form of a thread or bristle, sometimes resembling a dart or lancet, and fitted for piercing. The pharynx is the central point around which these portions arrange themselves after the tubular form. Sometimes the lower lip, united with the inferior portion of the maxillæ, and fixed like it, closes the cavity of the mouth, and the maxillæ then constitute a kind of spiral tongue. In other cases it is greatly prolonged, and assumes the form of an articulated tube, or of an elbowed trunk, usually terminated by two lips susceptible of dilatation. In either of the latter states it serves as a sheath to certain portions of a scaly structure and piercing nature, in the form of a bristle or lancet, and representing the other parts of the mouth. Sometimes this sheath (as in *Pulex*) is bivalvular, but it more frequently consists of a single piece laterally folded so as to form a tube open on the upper surface. In this longitudinal canal or gutter, the preceding parts are lodged, and compose by their general union the sucker, or *haustellum*. In some instances the palpi have disappeared, in others only two are visible. When there are four of these parts, two of them, the maxillary, are extremely small, or almost imperceptible. Sometimes, as among the pupiparous Diptera, the lower lip is either nonexistent or rudimentary, and the palpi become the sheath of the sucker. Though we make frequent use of the latter term, it may be remembered that its application is not strictly correct, as it is not by suction, or the production of a vacuum, that the alimentary juices mount towards the pharynx, but rather by the continuous pressure of the parts upon each other.

Of all the suctorial or haustellated tribes the Lepidoptera are those which differ least from the type of the mandibulated orders in the structure of the mouth,—on which account they have been made to follow in a supposed natural sequence the hymenopterous insects.[1] Their mouth seems to consist of a labrum and of two extremely small mandibles; of a trunk spirally rolled, improperly regarded as a tongue, and presenting interiorly and throughout its entire length three canals, of which, however, the central alone serves for the influx of the alimentary juices, and formed of two linear or filiform bodies, surrounding the pharynx at their origin immediately beneath the labrum. They represent, under peculiar forms and proportions, the terminal parts of the maxillæ, united, hollowed into deep gutters on their internal side, and bearing each a palpus, usually very small and tuberculiform. There is also a labium or lower lip, of a nearly triangular form, immoveable, united, as formerly mentioned, to the inferior part of the maxillæ, which supports the filiform or trunk-like portion, and bearing two triarticulate palpi, covered with scales or hairs, and placed on each side of the trunk, for which they form a kind of sheath. The intermediate canal of the trunk is produced, according to the detailed description given by Réaumur, by the union of the gutters of the internal face of the filiform or extended portions.

The sucker of the hemipterous tribes received from Fabricius the name of *rostrum*, a term translated beak (*bec*) by Olivier and other entomologists of France. A blade more or less linear, coriaceous, divided into three or four articulations, rolled up at the edges so as to form a conical or cylindrical tube, always directed inferiorly while inactive, and presenting along the centre of its upper or anterior surface a kind of canal produced by the opening left between the rolled-up margins,—a sucker composed of four slender, capillary, corneous, flexible, and elastic threads, disposed in pairs, but combined together, with the two inferior portions united in one at a short distance from their origin,—a small piece in the form of a triangular ligula, usually toothed at the extremity, rather coriaceous or almost membranous than of a scaly texture, and covering from behind or from the sides of the tubular body the base of the sucker, and inclosed along with it in the groove of the general sheath,—another piece of the same consistence with the preceding, corresponding by its insertion, and the position which it occupies, to the labrum or upper lip, covering from above the base of the sucker, most frequently itself

[1] Plate CCXXXIII. Fig. 5 exhibits the structure of the mouth in *Papilio Machaon*; *a* the head viewed in front, exhibiting the round eyes, one turn of the spiral proboscis, with the pilose labial palpi on each side; *b* shows the tubular spiral maxillæ (which by their union form the proboscis), with the vestiges of palpi at their base; the circular apertures on each side at the bottom of the figure indicate the insertion of the labial palpi; *c* represents the cleft labium and the two palpi, the left one being deprived of its scales to show the articulations; *d* is the minute labrum, with the mandibles on each side of it, ciliated on their internal edge. Fig. 8 exhibits the mouth of another lepidopterous insect, the *Lyndia cannarum* of Savigny; *a* the eyes, scaly spiral proboscis, and the four palpi; *b* one of the maxillæ, with its palpus; *c* the labium and palpus; *d* the labrum and mandibulæ.

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likewise inclosed in the sheath, and of a more or less elongated triangular form,—these are the parts which enter into the composition of the beak-like mouth or rostrum of the hemipterous tribes.[1] The single superior portion which Latreille regards as the analogue of the labrum, appears to cover, at least among the Cicadæ, the base of another more elongated and pointed portion, which has been viewed as corresponding to the epipharynx.[2] The other single and opposing portion, protecting from behind the origin of the sucker, and placed immediately behind the pharynx, represents, according to Savigny, the tongue or hypopharynx. The two superior filaments of the sucker, or those which are exterior, replace, or rather represent, the mandibles, while the two others may be regarded as maxillæ. Finally, the tubular sheath assimilates to the labium or lower lip, even in regard to its articulations. Sometimes the sheath is bifid, as in *Thrips;* sometimes it is divided into two plates, as in *Pulex*. The first of these genera is stated by Latreille to be the only one in which he has discovered palpi. He thinks that the parts taken for such by Savigny in *Nepa Neptunia* (Pl. CCXXXIII. fig. 6, as described in the preceding note), are more probably the rudiments of an articulation of the sheath. Germar indeed admits four palpi as characteristic of a new hemipterous genus of the family of Cicadariæ, named *Cobax;* but Kirby, who about the same period published an account of another generic group under the title of *Otiocerus*, and which offers analogous parts, does not regard these as palpi, but as simple appendages accompanying the antennæ.[3]

In the dipterous order, such as gnats and common flies, the mouth exhibits a great resemblance to that of the preceding tribes.[4] The union of the different parts forms what is usually in that order called the trunk or *proboscis*. We can here also distinguish the component parts of sheath and sucker. The former in dipterous insects is divisible into three principal portions; 1*st*, the *support*, distinguished from the following by an angular elbow, and frequently by a small geniculated article; 2*dly*, the *stalk;* 3*dly*, the summit, formed by two lips, sometimes membranous, large, vesicular, dilatable, striated, exhibiting through the microscope a great number of tracheal ramifications; sometimes coriaceous, and either small and slightly distinct from the stalk, or slender, elongated, and forming a more obvious article, almost as long as the preceding division (as in genus *Myopa*). The support is remarkable in this, that it results from the prolongation of the cutaneous membrane of the anterior and superior portion of the head, or the epistoma, united with the parts representing the labrum, to the mandibles, the maxillæ, and the inferior portion of the labium, as far as the mentum inclusive. This character particularly distinguishes the present tribes from those of the hemipterous order. In other respects the sheath may be said to be constructed on the same plan. The centre of the superior face of the stalk also presents a groove or gutter for the reception of the sucker. The number of pieces in the sucker varies according to an arithmetical progression of three terms, of which the difference is always two—2, 4, 6; but in all cases there are always two portions which are not paired, the one superior, representing the labrum; the other inferior, placed behind the pharynx, and the analogue of the tongue or hypopharynx. Among the Diptera, as well as in the suctorial tribe (*Pulex*), the latter portion is always scaly and piercing, and contributes, in common with the others, to the purposes of nutrition. It is otherwise with the Hemiptera, and this distinction forms a new character of separation between that order and the insects now under consideration. The parts representing the maxillæ always exist, and are frequently accompanied each by a palpus; but these maxillæ are soldered to the support, and are indistinct, except where their apical portion becomes moveable and elongated, and presents the form of a seta or horny lancet. This always takes place when the sucker consists of from four to six pieces. In the latter case two of them represent the mandibles; in the other, or where the sucker is composed of only four setæ, these are wanting, or merely rudimentary. Sometimes also the labrum, almost always vaulted and large, seems to offer the vestiges of another piece, which, under a fuller development, might no doubt be regarded as the epipharynx. Sometimes the support is very short, and in this case the pieces of the sucker leave the cavity of the mouth, and the maxillary palpi are inserted on the sides. The Hippoboscæ, or pupiparous Diptera, differ from all the rest in the absence of the sheath; for the palpi, under the form of two coriaceous elongated blades, perform its functions, and advancing in a parallel direction, cover and protect the sucker.

In accordance with the observations of Latreille, as well as with those of Savigny, Leclerc de Laval, and Professor Nitzsch, regarding the structure of the mouth in such of the hexapod insects as undergo no metamorphosis (*hexapodes homotenes*), the general plan of organization seems in these to be the same as among the polymorphous orders. In *Pediculus*, properly so called, the only known suctorial species of that division, the trunk (*rostellum*) consists of a small inarticulate tube, inclosing a sucker, and withdrawing itself at pleasure within a muzzle-shaped advancement of the anterior portion of the head. But the organization of these parasitical species requires a renewed and more careful examination. The genus *Ricinus*, although furnished with mandibles, maxillæ, and an inferior lip, has these parts greatly concentrated, after the manner of the Suctoria; and the labrum seems to perform the office of a cupping glass, a character unique and unexampled in this class of animals, and one which, in combination with certain other features, indicates a peculiar type.[5]

These are the principal modifications exhibited in the

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1 Plate CCXXXIII. Fig. 4 represents the mouth of *Cimex nigricornis;* *a* is the articulated labium, with the eyes at each side, and the first joint of each of the antennæ; this is the sheath for the other organs, and exhibits the groove on its oral surface; *b* is the sucker viewed from above, covered at the base for one third of its length by the tubulated labrum, and exhibiting at the extremity the straight united tip of the maxillæ, and the recurved ends of the mandibulæ; *c* is a view of the same parts separated, with the labrum removed to exhibit the expanded roots of the mandibulæ and maxillæ, the small opening of the pharynx, and the pointed lingua before it and between the maxillæ. Fig. 6 represents the mouth of another hemipterous insect, the *Nepa Neptunia* of Savigny, the labrum and palate being removed. The mandibulæ appear at the external sides, their summits with reflected spiculæ, and their roots near the pharynx flask-shaped. The tongue (in the interior of the figure) is trifid at the apex, underneath which the maxillæ arise, and exceed the mandibulæ in length. The labium, or central anterior portion, exhibits the groove for the reception of the other parts, and the oval raised marks towards the narrow end are the (supposed) vestiges of palpi.

2 *Diction. Classique d'Histoire Naturelle*, t. ii. p. 434.

3 *Linn. Trans.* vol. xiii. p. 12.

4 Plate CCXXXIII. fig. 7, where we represent the parts of the mouth of *Tabanus Italicus*. At *a* the mouth is shown as if opened, or the labrum and the mandibulæ and lingua separated, to expose the pharynx; *b* is one of the mandibulæ viewed laterally; *c* is one of the maxillæ with the articulated palpus, the last joint of which is greatly enlarged; and *d* exhibits the labium, with its fleshy lips.

5 *Diction. Classique d'Hist. Nat.* t. ii. p. 436.

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structure of the mouth by hexapod or true insects. In the opinion of Marcel de Serres, the parts named palpi (the antennulæ of some authors) enjoy, at least in the Orthoptera, a peculiar property, that of being the organ of the sense of smell. Lamarck again looks upon the palpi as exercising the faculty of taste. Latreille regards these opinions as ill-founded, so far as concerns a great number of insects, such as those in which the palpi are non-existent, undeveloped, or extremely minute; but he views them in a more favourable light in reference to certain other species. Thus, among the Coleoptera of the sub-family of *Xylotrogi*, the maxillary palpi of the males are lacinated or pectinated like some antennæ. In many other kinds the last article of the palpi is greatly dilated, and terminated by a pulpy substance.

We have not hitherto attended to the singular order Strepsiptera of Kirby (Rhipiptera, Lat.), the characters of which were first given in the *Linnæan Transactions.* If we regard the insects of this order as possessed of genuine mandibles, we must of course include them among the masticating tribes; but as in many of the preceding orders, in which the parts of the mouth are feebly developed, the mandibles are observed to have become obliterated, there is reason to suspect that the parts regarded as such in Strepsiptera are rather maxillary, in which case the structure would approach that of the lepidopterous kinds.

We have entered into the preceding details in consequence of the great importance which is now attached to the study of the parts of manducation. Latreille indeed seems to be of opinion, that whenever it is possible to characterize genera by more obvious organs, the minuter parts should not be had recourse to; and he deems the principles of the Fabrician system liable to abuse, especially when Clairville's example is departed from of employing only the mandibles and palpi. But the truth is, that the use of the compound microscope is scarcely ever required in these examinations; and it cannot be denied that a knowledge of such essential parts is indispensable in the formation of natural generic groups. The general physiognomy is frequently deceptive, and we can rectify our views only by recurring to influential organs. Thus the *Sphex spirifer*, and some analogous species which differ from their congeners in the mode of providing for their young, and which therefore form a good natural group, are also distinguished by an alteration in the structure of the mouth, but could scarcely be separated from the primitive genus by characters drawn from any other parts.

Besides the parts of the mouth, the head of insects presents some other component portions which have received particular names. What Mr Kirby calls the nose is that upper and anterior portion to which the labrum is attached, and which corresponds to the *clypeus* of Fabricius. (Plate CCXXXIII. fig. 1, *a*, upper portion.) The latter term was originally applied metaphorically to the expanded or shield-like covering of the head of the Scarabæidæ, and the expression was not inapt; but when it came to be used as a general term in relation to the structure of all other kinds, it lost its propriety of application. Hence the term *nasus* or *nose* has been substituted, as well as that of *epistoma*, which signifies the *part above the mouth.* Between the nose and the labrum we find in many species the nostril piece or *rhinarium* of Kirby. It is very obvious in a New Holland beetle, *Anaplognathus viridiæneus.* The *postnasus* may be seen under the form of a triangular piece, below the antennæ and above the nose, and separated from the latter and from the front by a deeply impressed line. It is very distinct in that splendid Chinese beetle the *Sagra purpurea.* The *frons* or front of insects is the middle part of the face, bounded laterally by the eyes, anteriorly by the nose or after-nose and the cheeks, and posteriorly by the vertex. The *vertex* is the crown of the head, and is bounded laterally by the hinder part of the eyes and the temples, and posteriorly by the occiput, when that part exists. It is the ordinary region of the stemmatic eyes, although these peculiar organs are sometimes found to occur likewise upon the frons. The *occiput*, or hind head, is that part which either forms an angle posteriorly with the vertex, or slopes downwards from it. It is bounded laterally by the temples, and posteriorly by the orifice of the head, or by the neck itself. The cheeks, *genæ*, according to Kirby, usually surround the anterior part of the eyes, lying between them and the mandibles, or their representatives. The temples, *tempora*, form a continuation of the cheeks to the posterior limit of the head, forming its sides and posterior angles.[1]

The *subfacies* of an insect is the lower surface or under side of the head, and is composed, 1*st*, of the *lora*, a corneous angular machine, upon the intermediate angle of which the mentum sits, and on the lateral ones the cardines or hinges of the maxillæ; it is by means of this piece that the parts of the mouth (as in *Hymenoptera*) are pushed forward or retracted; 2*d*, of the *jugulum* or throat, which is that part of the subface which lies between the temples. The *collum*, or neck, is that narrow portion of a pedunculate head by which it is connected with the thorax.[2]

The next appendages of the head to which we have to direct the reader's attention are the *antennæ.* These are moveable articulated organs, never exceeding two in number in genuine insects, although their form, and the amount of articulated portions, are extremely various. Their primary use in the animal economy has not yet been ascertained; at least a great diversity of opinion is maintained on the subject. In numerous tribes they seem to exercise a faculty analogous to that of touch, being employed in exploring the depth of crevices, and in ascertaining by contact the nature of any opposing obstacle; while, on the other hand, their extreme shortness in most Diptera, and in many of the neuropterous and hemipterous tribes, does not accord with that usage. Although of considerable importance in our systematic arrangement of insects, the development of the antennæ does not seem subjected to any general or conformable rules, and is therefore of less value than that of several other parts of structure. For example, we frequently find a considerable difference to exist in the form of the antennæ among species in other respects intimately allied; and even between the sexes of the same species a great disparity in size and structure is observable. Where a difference exists, those of the male are generally more developed than those of the female.

The antennæ of insects are usually composed of small cylindrical articulations, containing nervous threads, muscles, tracheæ, and cellular tissue. Various terms are in use to express their form, consistence, and mode of insertion. They are *regular* when the articulations follow a gradual and progressive order in the modifications which they undergo; *irregular*, when their forms alter suddenly; *cylindrical*, when rounded and of equal diameter throughout their length; *filiform*, when the cylindrical shape is finely attenuated, like a thread or hair; *setaceous*, when lengthened, and diminishing insensibly from the base to the point; *subulated* or *awl-shaped*, when slender, but short, cylindrical at the base, and terminated by a stiff and sharpened point; *moniliform*, when each article is rounded like a bead, and of nearly equal thickness; *prismatic*, when ap-

[1] *Introduc. to Ent.* vol. iv. p. 489.

[2] *Ibid.* p. 366.

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proaching the form of a geometric prism; *ensiform*, when broad at the base, and terminated by an angular point; *fusiform*, when shaped like a spindle; *serrated*, when each article is terminated laterally by a sharp tooth directed forwards; *pectinated*, when these projections are straight, lengthened, and placed above each other, like the teeth of a comb; *ramose* or *branched*, when several appendages project from the main body of the antennæ—they are regarded as *simple* when not in any way so adorned; *perfoliated*, when the articles are flattened from the summit to the base, and appearing as if strung on a thread through the centre (it is usually the terminal portion of the antennæ that is so characterized); *imbricated*, when the articles are threaded as above mentioned, and concave at their summit, so that each covers the base of that which follows; *clavated* or *club-shaped*, when thick or swollen towards the summit. The club is *solid* when its parts are not separated by any apparent space; *perfoliated*, when composed of threaded articulations; *lamellated* or *foliated*, when the parts of the club are connected laterally, and admit of being opened and closed like the leaves of a book; *securiform* or *hatchet-shaped*, when the last articulation assumes the form of a compressed triangle, free at the base, but articulated by the apex. Antennæ are also said to be *uncinated* or *hooked* when the extremity suddenly bends itself towards the base; *bifid*, when divided into two; *obtuse*, when terminated by a round or blunted articulation; *truncated*, when apparently deprived of a portion; *plumose*, when thickly branched on either side, like a feather. Many other terms are in use to express the modifications of these important organs, most of which, however, are of a sufficiently familiar derivation to explain themselves.

The antennæ of the coleopterous order usually consist of ten or eleven distinct articulations. The latter number is the most frequent, although several genera present much fewer joints, as for example *Paussus*, in which there are only two. Others again have many more, such as a species of Prionus, of which the antennæ of the female have nineteen joints, of the male twenty. In some orthopterous kinds these articulations amount to a hundred and fifty. The antennæ are inserted on the front of the head, anterior to and rather beneath the region of the eyes. Their particular position varies, but they are always either in the space between the eyes, or that below them. As their various forms, as characteristic of particular groups of species, will be afterwards described in the systematic part of the present treatise, we shall not here enter into further details of structure. The uses of these singular organs are variously viewed by naturalists, and there seems even yet to be more hypothetical reasoning on the subject than precise induction from facts. Some regard them as the seat of smell, others of hearing, a greater number as the organs of the sense of touch. The indurated nature of the outer covering in most insects would certainly lead us, *a priori*, to expect a special provision for the reception of the last-named sense. It is, however, extremely difficult, in the present state of our knowledge, to come to any general conclusion on the subject. We shall state the prevailing opinions when we come to treat of the senses of insects; and under that head we shall likewise explain the structure of the eyes.

The *thorax* forms the second principal portion of an insect's body. It is itself divisible into three parts, and its component segments vary greatly in their relative proportions in the different tribes; the division which is merely rudimentary in one particular group, being sometimes highly developed in another. These parts are named the *prothorax*, the *mesothorax*, and the *metathorax*.

The *prothorax* (from προ, *before*, and θωραξ, *thorax*) is the anterior segment, and corresponds to the *corselet* or collar of M. Latreille; the second segiment is named *mesothorax* (from μεσος, *middle*); and the third is known as the *metathorax* (from μετα, *after*). Each segment may likewise be distinguished in reference to its inferior, its lateral, and its superior portions; and the whole united constitute the *thorax*, commonly so called. But although the general name of thorax is applied to the parts just named, yet the posterior two, that is, the mesothorax and the metathorax, are the most dependent on each other, and are always intimately united; while the prothorax, as exemplified in the Coleoptera, is often comparatively free and distinguishable. It is this last-mentioned segment which bears the anterior pair of feet, and it considerably exceeds the others in extent. In the coleopterous order, indeed, it is the only part that is visible on the upper surface, the other segments, with the exception of the scutellum, being connected beneath it and the elytra. The mesothorax and metathorax unite strictly with the base of the abdomen, and serve as the points of attachment to the other pairs of feet. Of the mesothorax or central portion, the most obvious characters consist in its serving as a support to the second pair of feet, and to the elytra or first pair of wings. Its form, size, and consistence are extremely various. Slightly developed in the Coleoptera and Orthoptera, it is larger in the Hemiptera, the Neuroptera, and more especially in the Hymenoptera, the Lepidoptera, and the Diptera. Its excessive increase is always associated with a condition more or less rudimentary of the other segments. Thus, in the three orders last named, the prothorax and metathorax are very restricted; while, on the contrary, they are large in the Coleoptera, among which it is observable that the mesothorax is always compressed and narrow. The metathorax serves as the point of attachment to the third pair of feet, and to the second or membranous pair of wings.

We have said that each segment may be described in relation to its inferior, its lateral, and its superior parts. A piece named the *sternum* constitutes the whole of what is called the *inferior* portion. This is not, as too often supposed, an occasional projection, merely characteristic of certain tribes. It occurs in all insects, and forms a distinct character, though more or less defined and perspicuous, according to the genus. It may be regarded as generally composed of three distinct pieces, resembling in this respect the human sternum, which anatomists describe as consisting originally of three bones. Each of these pieces, according to Mr Kirby, is appropriated to a pair of legs, and each of them has been called the *sternum*; thus, in Elater the *prosternum*, in the Cetoniadæ the *mesosternum*, and in Hydrophilus the *metasternum*, have alike been distinguished by the name. Each of the ordinary *lateral* portions of the thorax is formed of two principal pieces, which, in combination with the sternum, is by some named the *pectus* or breast. The anterior piece rests upon the sternum, and is hence called *episternum* (from επι, *upon*). The posterior lateral portion, called the *epimera*, is connected with the preceding; it also adheres to the superior portion, and rests in certain cases on the sternum; but it bears a constant relation to the haunches of the segment to which it belongs, and to these it articulates by means of a little piece afterwards mentioned by the name of *trochantin*. It derives its name from επι, and μηρος, *thigh*. Lastly, there exists on these same lateral parts a third piece, in general slightly developed, and sometimes imperceptible. It bears relation to the wing and episternum, always supports itself on the latter, is sometimes prolonged inferiorly along its anterior margin, or, becoming free, passes in advance of the wing, or even places itself above it. It bears the name of *paraptera*, from παρα, *near to*, and πτερον, *wing*. Three other portions of some importance may likewise be considered as belonging to the general *pectus*.

1st, Above the sternum, on its internal face, that is, within the body of the insect, there exists a piece sometimes remarkable for its size. It is placed on the median line, and generally takes its rise from the posterior extremity of the sternum. It assumes various secondary forms, and is generally divided into two branches. Cuvier named it the Y-formed portion, on account of his having observed it assume the shape of that letter. It is called *entothorax* by M. Audouin, from ἐντος, *within*, because it is always placed in the interior of that organ. It occurs in each segment of the thorax, and seems to be in some measure a dependent on the sternum. Its uses are supposed to be the protection of the nervous system, and its isolation in many cases from the digestive apparatus and the dorsal vessel. The entothorax exists not only in the thorax, but in the head, in which case it is named *entocephalus;* it has even been noticed in the first ring of the abdomen in the genus *Cicada*, and the portion named *triangle écailleux* by Réaumur may safely be regarded as its analogue. In this last condition it is denominated *entogaster*.

2d, On the anterior edge of the episternum, sometimes of the sternum, and even on the superior part of the body, a stigmatic opening is observable, surrounded by a small piece, of which the texture is frequently corneous. This is the *peritrema*, so called from περὶ, *round about*, and τρῆμα, *a hole*. It is not always perceptible, both on account of its being sometimes too closely connected with the neighbouring pieces, and because the stigmatic opening is itself sometimes obliterated. But when visible, it is necessary that it should be distinguished, as its position is of importance, and becomes a useful auxiliary in the comparison of parts and in the determination of analogies.

3d, Lastly, it has been already stated in relation to the epimera, that it is connected with the rotule by means of a small articulation, of which the existence was first made known by M. Audouin. This is not an essential part of the thorax; but as it accompanies the epimera, and is associated with the parts of the leg, all of which have received particular denominations, its first describer has thought proper to bestow upon it a name. He calls it *trochantin*, in distinction to *trochanter*, or that portion of the leg which is associated with the rotule and the thigh. The trochantin is sometimes concealed in the interior of the thorax, and is sometimes visible externally, according as the rotule is itself more or less prolonged in its internal portion. The ascertainment of this piece, according to M. Audouin, admits of a direct comparison between the limbs of insects and those of the Crustacea. Hitherto there were only five parts in the former (the tarsi being regarded as one), while there were six in the latter. But the trochantin completes the number six likewise among the insect tribes.

We have now detailed the structure of the chest or pectus of insects; so that whoever desires to view one of these creatures anatomically, should, after dividing the thorax into three segments, seek to ascertain, on the inferior and middle portion of each, the existence of a sternum, and on the flank or lateral portion, an episternum, a paraptera, and epimera. He will also study the structure of the entothorax, of the peritrema, and of the trochantin. Sometimes, however, the union of one or more of these parts with another is so intimate that they cannot be isolated or distinguished; but when we elsewhere, in such numerous cases, perceive that the pectus is formed of a certain number of elementary parts, it is more rational to believe that in all instances these same elements are made use of, than to suppose the frequent requirement of new.

We shall next discuss the superior portion of the thorax of insects. In the coleopterous tribes the prothorax, as before mentioned, constitutes the principal portion, and its upper part may be called the *thoracic shield*. The only other part sufficiently distinguished prior to the time of M. Audouin, was the *scutellum* or escutcheon. It is highly developed in the Scutelleræ, and rudimentary in most of the Hymenoptera, Diptera, Lepidoptera, and some other orders. Its apparent position between the wings has occasioned its being regarded too exclusively as a kind of *point d'appui* in flight. It is usually of a triangular form in the Coleoptera, and projects backwards from the mesothorax, with its point interposed between the elytra and the wings. The scutellum was adopted by Geoffroy as the basis of his arrangement of the genus *Scarabæus*. It is, however, by no means a well-chosen characteristic of the greater divisions in entomology; for the accurate distinction is not, as is usually supposed, whether the scutellum does or does not exist in a lamellicorn insect, but whether it is or is not apparent.[1] It occurs very obviously among many of the coleopterous tribes, but is most conspicuously developed in that genus of the hemipterous order called *Scutellera*, of which *Cimex lineatus* may serve as an example. Naturalists have erred in regarding this portion as characteristic of the mesothorax alone. It is often greatly developed in the posterior segment. Numerous and varied researches have led M. Audouin to conclude that this superior portion of the thorax is composed of four principal pieces, frequently isolated, sometimes intimately united, usually distinct. He has deduced the following nomenclature from their relative position in regard to each other. The anterior portion is named the *præscutum;* it is sometimes very large, and is usually concealed in whole or in part in the interior of the thorax. The second piece is called the *scutum;* it is an important element, often strongly developed, and always articulates with the wings when these exist. To the next piece the original term *scutellum* is applied; it consists of the projecting angular point, generally so denominated by entomologists. The fourth and last piece is called the *postscutellum;* it is almost always entirely concealed within the thorax, sometimes united to the internal face of the scutellum, and confounded with it, sometimes free, and not adhering to the other portions, except by its lateral extremities. These are the parts which constitute the superior portion of the thorax, and to which the general term *tergum* may be applied. Thus we may speak of the tergum of the prothorax, of the mesothorax, or of the metathorax; but when the word tergum alone is used, we are then understood to signify the union of the superior parts, that is, the entire space comprised between the head and the first segment of the abdomen.

We come now to the *abdomen* itself, an important portion in the animal economy. Anatomists in general appear to have advanced from the study of the human frame to that of animals, or at least to have applied to the parts of the latter the same terms which they had previously bestowed upon the former. In so doing, however, they have been guided rather by the analogy of form than of function, and hence the vague nature of many terms, as applied to the inferior orders, and which, however correct in their original signification, become either obscure, or altogether inapplicable in regard to other classes.

The abdomen, among insects, is that part of the body which is attached to the posterior extremity of the thorax, composed of five or six rings or segments, unprovided with locomotive organs, and always containing within it a portion of the digestive canal. If, as many suppose, its existence depends upon that of the thorax, then the entire class of Annelides or red-blooded worms may be said to be deprived of it, as the thorax itself does not exist in that class.

[1] *Horæ Entomologicæ*, part i. p. 9.

The term body is then made use of to designate generally the whole of the animal. Although the abdomen cannot well exist without the thorax, the converse does not appear to hold good, for the latter in many species seems to constitute the whole body. Many of the *Myriapoda*, such as Iulus and Scolopendra, are examples of this; for they are composed of a series of segments, all furnished with feet except the last, which has therefore by some been regarded as the abdomen.

But among genuine insects, that is, the hexapod or six-footed kinds, the abdomen is obviously developed, and, especially among the winged tribes, is very distinguishable from the thorax. Among the apterous species the distinction is less perceptible; and the same may be said of most insects in the larva state. Among the hymenopterous kinds, such as wasps, bees, &c. it appears as if it were pediculated or attached to the posterior part of the thorax by means of a slender stalk; but minuter and more accurate observation demonstrates that this neck-like restriction actually takes place on the second segment of the abdomen, the first of which is much more spacious, but so closely attached to the thorax by its anterior edges as to become undistinguishable. In the coleopterous order the abdomen is usually convex, and of a harder consistence beneath, where it is exposed; but it is soft, and either flattish or concave above, where it is covered by the folded wings and elytra. On both sides of its segments there is a small roundish opening called the *stigma*, which serves for the introduction of air for the purposes of respiration, and of which we shall treat in detail when we come to the consideration of that function.

It has been noted that if an insect is naturally more habituated to walking than flying, the breast or lower portion of the thorax is expanded, and is furnished with more powerful muscles than the back; whereas, if flight is the more frequent mode of locomotion, an increase is observable in the dorsal muscles. The locomotive organs are of course the wings and legs, on which we shall now bestow a brief consideration.

SECT. III.—ORGANS OF LOCOMOTION IN INSECTS.

1. *The Wings.*

These organs exist, effectively, in insects only in the perfect state; for the larvæ do not offer externally any trace of them, and when apparent in the nymph or intermediate condition, they are merely rudimentary. No insect has more than four wings, many have only a single pair, and others are entirely destitute of these parts. When four in number they may be regarded as *anterior* or *superior*, and as *posterior* or *inferior;* and we likewise talk of the *first* or of the *second pair* of wings. The coleopterous order presents some peculiarities in relation to these organs. The anterior pair (in all cases, as already mentioned, united to the mesothorax) consist of a hard or horny substance similar to the envelope of the thorax, and are called *elytra*. When closed, their junction usually forms a straight central line called the *suture*, which is rather apparent than real in certain species in which the inferior wings are wanting, and the elytra form a single undivided piece. They are convex above and concave below, are fixed to the mesothorax, and cover and protect the genuine wings, which are of a much more delicate structure. These latter derive their origin from the metathorax, and are the actual organs of flight. They are membranous and transparent, and when unemployed are transversely folded beneath their horny covering. We shall here describe the structure of wings, and explain the terms made use of to express the principal modifications which they undergo in their various degrees of development in the different orders.

The wing of an insect consists of two thin flexible membranous transparent plates or leaves, the one superimposed upon the other, and variously intersected by darker lines of a horny consistence, usually known by the name of nervures. These nervures, which at first sight appear like superficial threads, of which the larger follow the longitudinal direction of the wing, are interposed between its membranes, and present two faces, of which the upper, frequently rounded and very horny, adheres closely to the corresponding leaf, and the under, of less firm consistence, and of a flatter form, may by skilful dissection be removed from that portion of the wing by which it is covered. In the opinion of M. Audouin, these threads are in fact so many tubes, which diminish in diameter as they approach the summit of the wing, and each of which contains, throughout its entire extent, a spirally rolled vessel, by some regarded as a genuine trachea. These tracheæ receive air from the interior of the body, and their formation, according to Swammerdam, whose views have more recently been confirmed and adopted by Jurine and Chabrier, is to strengthen the wing by distending it during the action of flight. They are said to experience no sensible dilatation during their progress, whereas the corneous tubes which contain them present in that respect some curious modifications,—for they sometimes spread out suddenly, in such a way as to exhibit, for a short space, a comparatively broad diameter. The colouring matter being then disseminated over a wider surface, assumes so pale an aspect that the nervure which leads into one of those little expansions appears as it were interrupted. Hence the name of *bulles d'air*, or air-bubbles, bestowed upon the latter by the French entomologists. They occur most frequently in the cubital nervures of many Hymenoptera, and their chief use is supposed to be to facilitate the formation of certain foldings of the wing during the periods of repose. The largest of the nervures arise from the base of the wing, that is, from the point of its insertion in the thorax. A most skilful observer, the late M Jurine of Geneva, has described the wings of hymenopterous insects with great accuracy, in a memoir to which we shall make more special allusion when we come to treat of that particular order.[1]

The general character in respect to form and aspect of the wings of insects has received a great variety of names. They are sometimes *equal*, that is, all four of similar size; or *unequal*, when one pair prevails over the other; *lanceolate*, when they become narrow, both at the base and apex; *falcated*, when curved like a scythe or reaping-hook; *linear*, when narrow, with nearly parallel edges; *clavated* or *club-shaped*, when linear in their general extent, but perceptibly enlarged towards their extremity; *rounded*, when they approach a more circular form; *oblong*, when more lengthened than broad, and describing an elongated ellipse, obtuse at both ends; *rhomboidal*, when they are longer from the posterior angle to the summit than from that angle to the base; *deltoid*, when they assume the triangular form of the Greek letter delta; *exserted*, when the inferior wings pass beyond the elytra; *covered*, when entirely protected by those organs; *plaited*, when longitudinally

[1] See *Observations sur les Ailes des Hyménoptères*, in the twenty-fourth volume of the *Mem. de l'Académie des Sciences de Turin*. Consult also, by the same author, *Nouvelle Méthode de classer les Hyménoptères et les Diptères*. Genève, 1807.

flight, but still preserve their primitive use. In the Neuroptera, particularly the Libellulina, they attain the development of the inferior wings, from which they differ but very slightly. From this point they continue to surpass them, until in the Diptera they become the sole organs of flight, and of course have there attained their highest degree of perfection. Arrived at this culminating point, they suddenly diminish in Hippobosca, and entirely disappear in Pulex.

We shall next devote a few lines to those portions of the wings called *ailerons* by the French naturalists, known also under the name of winglets or *alulæ*.[1] They are chiefly characteristic of the dipterous tribes, and may be regarded as appendages of the anterior wings, the sole pair in that particular order. Their attachment to the scutellum and the postscutellum of the mesothorax is sufficient evidence that they are not the rudiments of a posterior pair; for these, if they existed, would derive their origin from the metathorax. They usually consist of two concavo-convex pieces, intermediate as it were between the wing and the poisers, and folded the one upon the other, like the parts of a bivalve shell when the insect is at rest, but stretched or extended during flight. Their special uses are not yet known.

The poisers or balancers (*halteres*) have been sufficiently described in the preceding note. Audouin regards them as the rudiments of the second pair of wings, of which the extreme tenuity in the Diptera accords in his opinion with the evanescence of the metathorax.[2] Their use, like that of the last-named organs, seems not to have been satisfactorily determined. Dr Derham and others have thought that, like the pole of a rope-dancer, they keep the body steady in flight; while some connect them with the noises produced by insects, and maintain that they act upon the membrane of the winglet, as a drumstick acts upon its proper organ, thus producing sound. Shelver's opinion is probably more correct, that they are connected with the function of respiration.[3] But the various sentiments on the subject are as yet conjectural.

2. *The Legs.*

Having now endeavoured to explain the structure of the wings or organs of flight, we shall next request the reader's attention to those other organs of motion, the legs of insects. With the exception of the Myriapoda (*Centipedes*, &c.), which, with Latreille and Dr Leach, we shall form, as already noted, a separate class, the number of legs in insects is precisely six. They are composed of the following parts: 1*st*, The *coxa* or haunch, which is the first joint, or that which plays in the socket (Plate CCXXXIII. fig. 2, *a*); 2*d*, the *trochanter* or second joint, to the side of which the thigh is attached, and by means of which it inosculates with the coxa (Ibid. *b*); 3*d*, the *femur* or thigh, which is long, and usually compressed (*c*); 4*th*, the *tibia* or shank, generally the longest joint of the leg, and frequently notched on its edges, and terminated by spur-like appendages (*d*); 5*th*, the *tarsus*, composed of articulate portions, varying from three to five among the Coleoptera and the majority of insects (*e*). The last articulation of the tarsus bears the *ungues* or claws (*f*). M. Audouin and some other French naturalists seem to use the term haunch (*hanche*) as a collective designation, including an internal portion formerly noticed, called *trochantin*, along with the *rotule* (our coxa), and the trochanter. In accordance with this view, the parts of the leg in insects may be said to amount to six pieces, instead of the five which we have just enumerated. These terms apply strictly to the intermediate and hind legs. The anterior pair are by some writers regarded as *brachia* or arms. The first joint of the brachium, answering to the coxa of the legs, is named *clavicula*, or the clavicle, by Mr Kirby; its second joint, answering to the trochanter of the other limbs, is called the *scapula*; the third and elongated joint, corresponding to the femur, is designated the *humerus*; while the articulations of the tarsus are known as the *manus* or hand. However, the majority of authors seem not to express any distinction between the parts of the fore legs and those of the intermediate and hind ones. The anterior pair, we may observe, are in some cases convertible into organs of prehension, and their tarsi are frequently dilated in the male sex. The number of articulations of the tarsi varies in the different tribes, and is not always the same in the different pairs of legs in the same insect. Their amount on each limb has been assumed as a basis for the formation of the great sectional divisions of the coleopterous order, as originally proposed by M. Geoffroy, and so generally adopted by the continental naturalists. The character, though arbitrarily chosen, and not seldom artificial in its results, has proved upon the whole more compatible with a natural arrangement than usually happens on the selection of a single and uninfluential organ. We shall enter into further details in relation to this matter in our introduction to the coleopterous order, and shall merely observe in the mean time, that pentamerous species, or those of which all the tarsi are furnished with *five* articulations, are the most abundant,—more than one half of the coleopterous kinds being referable to that section.

These are the principal external parts of the structure of insects.[4] Their internal conformation has been illustrated of late years by the successful efforts of several very skilful and ingenious observers. We shall here notice the dominating or more influential organs, and give a short view of the important vital functions which they exercise.

CHAPTER III.

THE INTERNAL STRUCTURE AND PHYSIOLOGY OF INSECTS.

SECT. I.—THE NERVOUS SYSTEM AND SENSES OF INSECTS.

The nervous system of animals in general, it has been remarked, is one of the most wonderful and mysterious works of the Creator. Its pulpy substance is the visible medium by which the governing principle (Το Ἡγεμονικον) transmits its commands to the various organs of the body, which instantaneously obey the impulsive mandate; yet this appears to be but the conductor of some higher principle, or

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dites, or those of the aquatic larvæ of Ephemeræ and the genus Gyrinus. He founds his opinion chiefly on this, that the inferior wings always take their origin from the lateral and anterior summits of the third thoracic segment, at a very short distance from the superior wings, and always in advance of the two posterior stigmata of the thorax, whilst the balancers are inserted lower down at the internal extremity of these air-conduits, or close by them. (See Latreille's observations in the 7th and 8th volume of the *Memoires du Museum d'Histoire Naturelle.*)

[1] We have made use of the term *wing-scale* in the systematic exposition afterwards given of the order Diptera. Meigen uses the German word *schuppchen* (squama) in his *Zweiflugeligen Insecten.*

[2] *Dict. Class. d'Hist. Nat.* t. ii. p. 141.

[3] Wiedeman's *Archiv.* ii. 210.

[4] For some additional details, we beg to refer to a paper entitled "Osteology, or External Anatomy of Insects," by Mr Newman, in the *Entomological Magazine*, No. IV. We had not an opportunity of consulting it until our own abstract had been composed, chiefly from foreign sources.

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more ethereal essence (language is ransacked in vain for an appropriate term), which can be more immediately acted upon by the mind and will. But this supposed principle, by whatever fond or fantastical name it may be known, whether as a nervous *fluid* or a nervous *power*, has never been detected by the most subtile physiologist, and is known only by its effects. It is, however, undoubtedly the centre from which all power and function flow; and during the absence of worthier substitutes we need not challenge the vague abstractions of some metaphysical inquirers.

The nervous system of insects consists of a homogeneous pulp, usually disposed in twelve successive ganglions, connected by a double cord. We first observe a double or bilobed mass, which, as it is placed in the head, may be called the brain. It is surrounded by strong muscles, and from its anterior portion nerves are distributed to the eyes, antennæ, and mouth. Posteriorly two delicate recurrent nerves proceed towards the dorsal vessel, and inferiorly two larger nerves, after having formed by their branching a kind of ring, which embraces the œsophagus, unite in the form of a ganglion beneath the last-named organ. From the posterior part of this latter ganglion a pair of nervous cords proceed for a space, and then by their union produce a second inferior ganglion, from which the nervous cords again branch off posteriorly, and so uniting and ramifying from space to space, they extend through the different segments of the thorax and abdomen. The number of these ganglia varies; sometimes they correspond to the divisions of the body, while in many instances they are of smaller amount. In the larva of the rhinoceros-beetle, for example, the whole spinal cord (so called from its supposed analogy to the part known by that name among the vertebrate kinds) presents the appearance of a single ganglion, divided merely by transverse furrows,—while in that of a dragon-fly, six have been observed in the thorax, and seven in the abdomen. In the great water-beetle (*Hydrous piceus*) the head exhibits one ganglion, the thorax six, and the abdomen only two. In the honey-bee there are three ganglia in the thorax, and four in the abdomen. When we examine these knots attentively, we may perceive that, in addition to the double and longitudinal nervous cord by which they are connected, they throw off laterally on either side small nervous trunks, which divide into branches, and finally ramify over the muscles, the intestinal canal, the tracheæ, and other parts. This nervous system differs considerably in the larva and perfect insect. In the latter the ganglia are usually less numerous, and the posterior appear formed by the close approximation of several others.

The principal ganglia of the nervous system of insects are frequently thus disposed. The position of the upper or cervical ganglion has been already mentioned. The others rest beneath the intestines, ranging along the inferior face of the body. There are three in what may be called the chest; that is, one in the prothorax, which sends nerves to the anterior legs; one in the mesothorax, which supplies the elytra or the upper wings, and the middle legs; and one in the metathorax, which distributes its filaments to the second pair of wings and the last pair of legs. The other ganglia belong to the abdomen. Insects are characterized by the ganglionic distribution of the nervous system, in common with the Crustacea and Arachnides on the one hand, and with the Vermes or worms on the other. But in insects the ganglia are larger and less numerous than in the still lower tribes, which gives a more decided character of centricity to their nervous system. Indeed the highest manifestation of this character is usually presented only as the ultimate result of several metamorphoses; so that while the larva exhibits a closer agreement with the nervous system of worms, that of the imago or perfect insect assumes a higher development. It does not however appear that the brain or upper ganglion of insects acts in the capacity of a *sensorium commune*, as among warm-blooded animals, such as mammiferous quadrupeds and birds; for many insects will live for a considerable time, and even exercise their faculties of flight, after the loss of parts which among the other class we justly regard as of vital importance. The tenacity of life in horse-flies, for example (*Hippoboscæ*), is very remarkable. When deprived of their heads, and replaced upon a horse, they will be perceived to run backwards and forwards and sideways, with apparently the same case as prior to their decapitation.[1]

The ganglions themselves frequently exhibit a bilobed structure, which appears to result from the union of two smaller masses, originally distinct. Comparative anatomy tends to confirm this supposition. M. Marcel de Serres[2] maintains that the nervous system of insects, and of all invertebrate animals, corresponds to the eccentric portion of that system among the higher classes, that is, to the intervertebral ganglia and their radiations.[3] In the primitive state of larva he deems the nervous system to consist of two distinct portions, a right and a left; and he maintains that the formation of the nervous system in all animals proceeds from the circumference to the centre, and not, as usually supposed, from the centre to the circumference. We know well, from the observations of Carus and Tiedeman, that the organs of the inferior animals repeat, as it were, the forms which present themselves only in the *embryo* condition of the higher tribes. M. de Serres endeavours to show that it is by the progress of successive developments that the portions of the nervous cord in insects approach each other,—that they first join around the œsophagus, then at the opposite extremity towards the inferior ganglions, and lastly in the central parts. He thus admits three distinct embryo states in the condition of the larvæ; first, that in which the two portions of the nervous system are entirely isolated and distinct; secondly, that in which the œsophagian ganglia are alone united; and, thirdly, that in which the opposite extremities are joined together. By means of this distinctive view, the French physiologist connects the nervous system of insects with that of the Mollusca, the latter presenting the embryo con-

[1] *Entomological Magazine*, No. iii. 301.

[2] *Ann. des Sciences Nat.* t. iii. p. 377.

[3] The relation which the nervous system of invertebrate animals bears to that of the vertebrated tribes has, however, given rise to many conflicting opinions. "Among the various suggestions on this point, are that of Ackermann and Reil, who viewed the nervous system of Articulata as corresponding to the sympathetic system of vertebral animals;—of Walther, who compared it in the Mollusca to the par vagum, and in the Articulata to the spinal marrow;—the most generally received opinion, however, is that supported by the authority of Meckel, Cuvier, Blumenbach, Gall, and Spurzheim, who compare it in the Articulata to the cerebro-spinal cord of vertebral animals. The latter gentlemen, in particular, have furnished a strong proof of the correctness of this idea, by demonstrating that the spinal cord of the superior animals actually consists of a series of ganglia with intermediate contractions,—a structure most fully developed in the Articulata. Rudolphi (*Physiologie*, b. ii. s. 8, 1823) adopts the same opinion, and notices the fact, that in Mollusca, Crustacea, Insects, &c. we find nerves of sense arising from the cerebral ganglia,—which by no means accords with the character of the sympathetic system." (See Note to Carus's *Comparative Anatomy*, by Gore, vol. i. p. 69.) E. W. Weber (*Anatomia Comparata Nervi Sympathetici*) appears to have been the first to suggest that the ganglia on the knotted spinal cord of articulated animals correspond to the intervertebral ganglia of the spinal nerves of the higher classes, rather than to the segments of which their spinal marrow is composed.

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dition of the former, that is, being permanently distinguished by a characteristic which is only temporary among the articulated tribes. This may probably be regarded as an additional argument in favour of what we shall afterwards endeavour to maintain,—the general superiority in the scale of organization of the annulose classes over the molluscous kinds. We shall conclude by observing, that besides the general protection afforded by the external envelope of insects to their nervous system, it is specially protected by the Y-shaped portion formerly described.

As the nerves constitute the principal media of sensation in all animals, we shall here give a short sketch of the different senses of the insect class.

Of the senses in general, as they exist in man and the higher beings, physiologists and metaphysicians alike enumerate the following *five*, viz. *touch*, *taste*, *smell*, *hearing*, and *sight*. All of these, we doubt not, exist in the class now under consideration, although we are not in every case acquainted with the special organ by which each particular function is exercised.

The sense of *touch* is usually regarded as affording animals, and man especially, a more intimate and assured communication with the external world than those of either sight or hearing, in as far as no intermediate substance comes between us and the subjects of perception. The perfection of the sense depends on the quality of the skin, the extent and nature of its surface, the number of its nerves, its freedom from insensible parts, and the delicacy of those appendages which are more particularly destined to the examination of bodies. As touch is the most important of all the senses, it may naturally be inferred to be finely developed in the human race; and we know that, of all the vertebrated animals, man in that respect is one of the most highly organized. But among the invertebrate kinds the sense of touch improves in proportion as the others degenerate; and those which have no other sense possess it so exquisitely that some of them seem even to *feel the light*.[1]

Among insects the sense of touch varies remarkably according to the condition in which they happen to exist for the time,—their exterior surface, in which the function exists, or at least through which it must be manifested, being itself subject to great variation, even among individuals of the same species. When soft, as in the larva state, the skin is extremely delicate in its perceptions, and capable of transmitting the most lively sensations; while in the imago or perfect condition, more especially among the Coleoptera, its harder consistence renders it chiefly serviceable as a protecting covering. In this case the feet, palpi, and, as many suppose, the antennæ, seem the principal organs of the sense of touch.

The sense of *taste*, which some regard as an exalted modification of the perception of touch, is very obvious among insects. We see many species, while searching after food, reject or only partially consume whatever is disagreeable or unexpected, while they gloat over a more favourite morsel. The organ in which the sense is placed is not, however, so easily determined. Some regard the palpi, and others the pharynx, as its principal seat. That portion of the labium which the French naturalists name the languette or ligula, has also been regarded as exercising the sense of taste. It is certain that distinct nerves are distributed to that quarter, as represented by Lyonnet in his great work on the caterpillar of the cossus.

The sense of *smell* is exquisitely developed in the insect tribes. No sooner has an animal fallen, from age or sickness, even on the loneliest and most barren moor, where perhaps no vestige of insect life was previously perceptible, than troops of flies and carcass-eating beetles assemble from every quarter, led by the emanation of the tainted air.

It was in truth the influence of the sense of smell that in ancient times no doubt gave rise to so many erroneous ideas regarding the origin of insect life. Every animal body in a state of decay being seen to present a crowd of small larvæ or worms, these were regarded as the *produce* of corruption, whereas they resulted naturally, and according to the usual course, from eggs previously deposited by parent flies or beetles, which had been attracted by the putrid effluvia. It is not two hundred years since Redi proved for the first time, by conclusive experiments, that this was true. It is also known that bees will discover and hover around a box containing honey, though their prized treasure is screened from sight; and both flies and beetles are so affected by the perceptions of this sense, that even their peculiar and all but unerring instincts are occasionally deceived by its influence. They will deposit their eggs on plants which are characterized by a fœtid smell (for example, on the *Phallus impudicus*), misled by the resemblance of their flesh-like odour, which the experience of the sense of sight cannot rectify.

The scent of many flowers is cadaverous, and is thus the means of assembling around their deceptive petals numerous insects which feed on putrid matter. It is thus that the spathes of the *Arum dracunculus*, and the corolla of the *Stapelia variegata*, are frequently found covered by Silphæ, flesh-flies, and other species, which not only attempt to feed upon them, but also deposit their eggs in what they conceive to be a fitting station. But the seat of this indispensable faculty is likewise still involved in obscurity. On a subject so difficult of solution, and which can only be solved by a consummate knowledge of anatomical structure, viewed in relation to the uses of physiology, it would not become us to offer an opinion, or do more than report the sentiments of those who are necessarily more experienced than ourselves. Many agree with Dumeril in maintaining that in insects the sense of smell is effected, as among the higher animals, through media in very intimate connection with the process of respiration; in other words, that either the *tracheæ* or stigmatic openings are the seat of its exercise. Others again suppose, that for the exercise of so important a function, a more special and concentrated organ is required; and proceeding upon the analogical relation of mere position, they regard the antennæ as its seat. These receive the first pair of nerves, and so far correspond to the olfactory organs of the higher animals, which are likewise connected with the brain by means of the first pair. The question is one which is extremely difficult of determination, especially in reference to the singular experiments of Huber on bees, which go far to prove that the sense of smell, at least in these hymenopterous species, is placed in the cavity of the mouth.

Christian maintained that insects exercised the sense of smell in relation to distant objects through their antennæ, and in regard to near ones by means of their palpi; while Comparetti imagines that in the different tribes of insects different instruments are subservient to that end. Cuvier, at least in his earlier works (and we are not aware of any recorded change in his sentiments) favoured the opinion already alluded to regarding the respiratory organs. "As the organ of smell," he observes, "in all animals which respire air, is situated at the entrance of the organs of respiration, the most probable conjecture that has been pro-

[1] *Leçons d'Anatomie Comparée*, sect. 14.

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posed respecting its seat in insects, is that of Baster, since revived by several naturalists, who placed it in the mouths of the tracheæ or air-tubes. In addition to the reasons hitherto stated in support of this opinion, we may observe that the internal membrane of the tracheæ appears very well calculated to perform this office, being soft and moistened, and that the insects in which the tracheæ enlarge, and form numerous or considerable vesicles, are those which seem to possess the most perfect sense of smell. Such are the Scarabæi, flies, bees, &c. The antennæ, which other anatomists have supposed to be the seat of smell in insects, do not appear to us to possess any of the conditions for that organ."[1]

Huber's experiments, undertaken with a view to ascertain the seat of smell in bees, consisted in presenting successively to all parts of their bodies a hair pencil dipt in oil of turpentine, an article which they particularly abominate. When made to approximate the head, trunk, or abdomen, it produced no particular effect, and the odour appeared to be equally disregarded by the antennæ and proboscis. But when he brought the point of a fine hair pencil saturated in the oil almost into contact with the cavity of the mouth, above the insertion of the proboscis, the bee started back in an instant, quitted its food, clapped its wings, and would have taken immediate flight had not the pencil been removed. A repetition of the experiment produced the same signs of discomposure; and similar results, but more prompt and sure, followed the use of oil of marjoram. The indefatigable Genevese observer then stopt up the mouths of several bees with paste, which soon became comparatively hard and dry. In this state they were quite insensible to those odours which had previously produced such painful effects.[2]

Mr Kirby maintains an opinion different from any we have yet alluded to, though more allied to the last than to the others. As the nose of an insect evidently corresponds with the part so named in the Mammalia, not only in its situation, but frequently in its form, and as a constant connection may be observed to obtain between the senses of smell and taste, he felt convinced in the first place that the argument from analogy was wholly in favour of the nose, or anterior portion of the head formerly mentioned under that name. The common burying beetle (*Necrophorus vespillo*) is an insect remarkable for its extreme accuracy and acuteness of smell. While examining the nose of this insect, Mr Kirby observed in the middle of its anterior part a subtrapezoidal space, as it were cut out and filled with a paler piece of a softer and more membranous texture. On dividing the head horizontally, he perceived beneath the nose, and partly under the space just mentioned, which he calls the *rhinarium* or nostril piece, a pair of circular pulpy cushions, covered by a membrane transversely striated with beautifully fine lines. These are what our learned author regards as the organs of smell, and he noted that they remained distinctly visible in a specimen which he had had by him for more than fifteen years.[3]

Hearing is perceptibly acute in some insects, and of more doubtful existence in others. The frequent and various sounds to which many species give utterance have been adduced in proof of their being endowed with this perception; for we cannot but suppose that the shrill voice of the grasshopper, and the evening song of the cricket, are subservient to some essential end, which they cannot well be if unheard by their blythe companions. The small wood-devouring beetle called the death-tick (*Anobium*), answers its neighbour's call as regularly as a cock crows a response to its pugnacious rival; and Derham, when he kept these insects in captivity, by imitating their tiny call, could make them click when he pleased. What is called the voice in insects is usually produced by the friction of certain hard and horny parts of the limbs upon some other portion of the body of a like consistence. In others it is effected by a rapid vibration of the wings; and a few beetles seem to give utterance to a shrill and sometimes plaintive cry by rubbing the terminal segments of the abdomen against the curved points of the elytra. This power of voice, as we call it for want of a better name, is often possessed by the males alone; and as it is used as a call of love in spring and summer (most obviously so among the Cicadæ), we infer the sense of hearing in the females of that family, and consequently in the class of insects.

Brunelli kept some large green grasshoppers (*Acrida viridissima*) in confinement. They used to sing all day in a closet, but ceased when any one gave a rap upon the door. He learned by degrees to imitate their chirping call. At first a few of the boldest would answer him, and then gradually the whole band would strike in and sing with all their might. On one occasion he inclosed a male in his garden, and gave the female her liberty; but no sooner did the husband begin to solace his captivity with a song than his quondam partner recognised the accustomed voice, and flew towards him without delay.[4] In relation to this subject Dr Wollaston makes the following curious observation. "Since there is nothing in the constitution of the atmosphere to prevent vibrations much more frequent than any of which we are conscious, we may imagine that animals like the *Grylli*, whose powers appear to commence nearly where ours terminate, may have the faculty of hearing still sharper sounds, which at present we do not know to exist; and that there may be other insects, hearing nothing in common with us, but endued with a power of exciting, and a sense that perceives, vibrations indeed of the same nature as those which constitute our ordinary sounds, but so remote that the animals who perceive them may be said to possess another sense, agreeing with ours solely in the medium by which it is excited, and possibly wholly unaffected by those slower vibrations of which we are sensible."[5]

The precise position, however, of the organ of hearing in insects has not been determined with precision. In the Crustacea it is found at the base of the large antennæ; and Latreille has satisfied himself of its existence in a similar situation in an orthopterous insect called *Gryllus lineola*. Mr Kirby is of opinion that the *primary* use of the antennæ is to exercise a function analogous to that of hearing, and Mr Rennie entertains a similar sentiment.

The sense of *sight* is too obvious in this class to require demonstration. The eyes of insects are, however, of a very different nature and construction from the exquisitely formed visual organs of the higher tribes. They consist of two kinds, the *composite* and the *simple*. The latter, known under a certain form likewise by the name of ocelli or stemmatic eyes (*stemmata*), are sometimes wanting, sometimes co-existent with the others.[6]

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[1] *Comparative Anatomy*, vol. ii. p. 687.
[2] *Nouvelles Observations sur les Abeilles*, t. ii. p. 375.
[3] *Introduction to Entomology*, vol. iv. p. 254.
[4] Lehmann, *De Sensibus Externis Animalium Exsanguium*, 22.
[5] *Phil. Trans.* 1820, p. 314.
[6] What Messrs Kirby and Spence name *conglomerate* eyes do not essentially differ from simple eyes, collected together in a compact bundle. They occur in *Lepisma*, and many Myriapoda.

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The composite eyes generally form, as it were, the lateral portions of the head. They are either entire, notched, or even occasionally so completely divided by a little corneous stalk, as to exhibit (for example in the genus *Gyrinus*) the appearance of a pair on either side. In other respects their forms are extremely variable—their surfaces more or less convex. These compound eyes are composed externally of a hard and transparent membrane (softer in the dipterous tribes), which presents an infinity of small hexagonal surfaces, disposed with the most exquisite regularity. This peculiar structure prevails equally on the concave or internal, as on the convex or external surface. The structure and composition of the eyes of insects have been carefully studied and explained by Leeuwenhoeck, Swammerdam, Cuvier, and more lately and laboriously by Marcel de Serres. We shall here avail ourselves of the *resumé* given by M. Victor Audouin.[1] In the eye of an insect we observe, 1*st*, a cornea (convex in proportion to the carnivorous habits of the species), transparent, hard, thickish, generally encased in a groove of the head, and exhibiting many thousand regularly disposed, hexagonal facettes, each of which is in itself a perfect eye. These are sometimes so numerous that not fewer than 34,650 lenses have been counted in the head of a butterfly, and the coleopterous genus *Dynastes* of Macleay is supposed to be still more wonderfully and exuberantly supplied. 2*d*, An opaque, slightly liquid matter, variously coloured, frequently deep violet or black, but sometimes red or green, tenaciously adherent to the inner face of the cornea, and distinct from the deep-black varnish of the choroid. It is by no means rare to observe various colours united in the same eye, which then appears beautifully mottled, as in many species of the orthopterous, neuropterous, and dipterous orders. These tints, however brilliant in the living state, speedily vanish after death. They are always owing to this peculiar coating of the cornea. 3*d*, A true choroid, covered by a dark varnish, which may be regarded as a *pigmentum nigrum*. The lynx-eyed Swammerdam failed to distinguish this coating from that of the cornea; but, in the opinion of Marcel de Serres, it is really different. The choroid and its pigment do not always exist in insects. They are wanting in the *Blattæ*, and in all the lucifugous or light shunning species, such as those of the genera *Blaps*, *Tenebrio*, and *Pedinus*. In these cases, it has been remarked that the covering of the cornea is much deeper than usual. The choroid membrane is fixed by its circumference to all the margin of the cornea, of which it follows the contour, and is intimately connected with the tracheæ, which are there so numerous. 4*th*, Air vessels which play an important part. They take their rise from larger trunks which are situated in the head, and form around the eye a circular trachea, which sends forth an infinity of branches, producing by bifurcation a number of isosceles triangles. These triangles, of which the base is outwards, are placed around the optic cone, and receive, in each angular interval which separates their summits, a nervous filament, which traverses the choroid, and reaches the external surface of the covering of the cornea. The assemblage of tracheæ and nervous threads forms at the circumference of the eye a peculiar kind of network, of which the aspect is beautiful to look upon. The tracheæ themselves are so abundant on the choroid, that that membrane appears to be composed of them; and it may also be noted, that in those genera in which the choroid is wanting, the circular trachea is likewise absent.[2] 5*th*, Nerves arise from a principal branch which, after proceeding immediately from the brain (or upper ganglion), is either encompassed by a little circular trachea, or traverses the fibres of the abductor muscle of the mandibles. This branch soon augments in volume, and forms a kind of cone more or less extended, of which the base is towards the transparent cornea. Numerous nerves proceed from that base, mingle with the tracheæ of the choroid, traverse both that membrane and its pigment, penetrate the lining of the cornea, and finally terminate each on a facette of the transparent cornea, so that the nervous filaments are thus immediately in contact with the light, which reaches them after having traversed only the last-named organ. This disposition of the nervous threads, which thus constitute as many small retinæ as there are facettes in the cornea of the eye, is very distinguishable in *Libellula*, *Truxalis*, and *Gryllus*. The eyes of insects, then, contain no humours properly so called,—neither vitreous nor crystalline,—and vision is consequently much more simple with them than with the vertebrated tribes, in which the nerves are placed deeper in the eye, and do not receive the rays of light till these have passed through media of different densities.

The simple or *stemmatic eyes* of insects are usually three in number, and are placed on the crown of the head, between the genuine organs of sight, from which their structure differs. In spite of their extreme minuteness, Marcel de Serres has succeeded in detecting the following component parts. 1*st*, A transparent cornea, formed by an external membrane, hard, convex externally, and smooth, that is, exhibiting no appearance of facettes. 2*d*, Of a variously-coloured matter, which lines the internal face of the cornea, but which is perhaps not essentially distinct from the varnish of the choroid. It varies in colour, being almost always black in Hymenoptera, usually whitish in Orthoptera, and, in many caterpillars, yellow, red, or green. 3*d*, A kind of choroid, rather thick, more extended on the surface than the cornea itself, sometimes of a black colour, more frequently red, and occasionally of a peculiar whitish hue. 4*th*, Tracheæ, which do not derive their origin from a circular air vessel, and do not, as it were, constitute the choroid, but appear to be distributed over its surface. 5*th*, Nerves proceeding either directly from the brain or upper ganglion, or from another more considerable nerve or common trunk, according as these simple eyes are separate from each other, as in perfect insects, or closely approached, as among larvæ. In their passage towards the eyes they are attached to the neighbouring parts by tracheæ or air vesicles, and do not appear to present any swelling; they pass between the motive muscles of the different parts of the head, traverse the choroid and its varnish, and expand upon the internal face of the cornea, where they are surrounded by the layer of pigment belonging to that membrane. Thus, on examining the simple or stemmatic eyes of insects, and proceeding from the circumference to the centre, we meet with a transparent cornea,—a pigment, which lines its inner face,—the termination of the optic nerves,—the pigment of the choroid, when distinct from that of the cornea,—and the choroid itself, which frequently rests upon a large trachea. The principal character of these simple eyes consists in this, that each is a single organ, whereas the composite eyes, as the name implies, are formed by the union of many. The one kind is most characteristic of the larva state, the other of the perfect insect; but several orders, even in the last-mentioned condition, possess both organs.

[1] *Dict. Class. d'Hist. Nat.* t. viii. p. 554.

[2] Muller and others appear to entertain a different view from that given above. The subject is one of considerable complexity, and our present limits prevent our entering into its various and sometimes contradictory details. We refer the curious reader to a series of papers on the visual organs of insects and Crustacea in the fourth volume of the *Naturalist's Magazine*.

Thus, with few exceptions, the Orthoptera, Hemiptera, Hymenoptera, Neuroptera, and Diptera, possess both simple and compound eyes. Dr Carus however states that the stemmata do not exist either in beetles or butterflies; a most erroneous opinion in regard to the latter, in which they exist universally, although not always detected; and incorrect as to the former, in several of which they have been distinctly seen. They are visible in Gravenhorst's genus *Omalium*, or at least in some of the species;[1] and Mr Kirby found them very conspicuous in *A. Caraboides*, and other Anthophagi. They are wanting in Strepsiptera, Dermaptera, and Aptera.

Although neither Linnæus nor Fabricius, those great masters in the science, gave any explanation of the uses of the stemmata, there can be no doubt that Swammerdam and Réaumur were correct in regarding them as genuine eyes.[2] The French writer supposes that the compound organs have the power of magnifying, and are used for surveying more distant objects, while the simple ones possess little of that power, and are employed on objects close at hand. Blumenbach is also of opinion that the polyhedral eyes are for viewing distant objects, and the simple ones for such as are near.[3] This is in some measure confirmed by the fact, that while most insects in the perfect state have large compound eyes, caterpillars and other larvæ have usually small myopic ones. On the other hand, the Mole cricket (*Gryllotalpa*), a truly subterranean species, is furnished with both kinds. Réaumur's experiments on the visual organs of bees are extremely important in relation to our present subject. He smeared the compound eyes with paint, when the insects, instead of directing their flight towards the hive, ascended in the air till they were lost to sight. He then treated the stemmatic eyes in the same manner, and placing his patients near their hive, they winged their way on all sides among the surrounding flowers, but neither ascended into the air, nor flew far from home. From these experiments it has been supposed that the compound eyes are for horizontal sight, and the stemmatic for vertical.[4] Spix imagines that what we call simple eyes in insects are in fact olfactory organs.[5] Nothing can be adduced in support of a theory so fantastical.

We shall conclude this branch of our subject by observing that some insects are supposed to be entirely destitute of eyes. This is the case, according to Rudolphi,[6] with the coleopterous genus *Claviger*, in which there are certainly no apparent eyes; and Marcel de Serres observes, "un assez grand nombre de larves à metamorphose complète n'ont point d'yeux du tout."[7]

SECT. II.—THE RESPIRATORY SYSTEM IN INSECTS.

Though insects respire air, they do not receive it, like the majority of vertebrated animals, through nostrils or other orifices in the head, but by means of numerous small openings along the sides of the body, and which lead not to lungs, but to a system of air vessels ramified *ad infinitum* through every part of the body. The respiratory organs of this class are composed of *stigmata*, *tracheæ*, and *bronchiæ*. The first, called also spiracles or breathing pores, consist of small perforations of various forms, placed along the lateral portions of the body, and generally incased externally in a small corneous ring, though sometimes pierced in the membrane which separates the dorsal from the ventral surface. These stigmatic openings occur both on the thorax and abdomen, and lead inwards to the tracheæ. Their number varies according to the species, and even in the same species according to the temporary condition of the individual. They are wanting on the second and third segments of the body of the larva; and as it is from these segments that the wings are developed, M. de Blainville has been induced, probably by that circumstance, to regard the organs of flight as reversed and expanded tracheæ. The existence, however, of stigmatic openings on the thorax of the perfect insect simultaneously with the wings, militates against this theory; for if these parts were convertible, would they not be likewise each exclusive of the other?

Parallel with the sides of the body of most insects, and extending its whole length, run two cylindrical tubes, which communicate with the spiracles, and give issue, at points opposite to those organs, to other tubes, the ramifications of which are distributed over all the membranes, penetrate the muscles, and pervade even the legs and wings. They also envelope the dorsal vessel and digestive organs, and demonstrate that the ultimate aim of respiration is assimilation, or the increase and reproduction of organic molecules, by the decomposition of food. The first of these tubes are called the tracheæ, the latter the bronchiæ. This structure, however, cannot be regarded as universal, as in many of the lamellicorn beetles the bronchiæ spring directly from the spiracles, the interior mouth of which is lined by a membrane from which they proceed.[8] But a volume would scarcely suffice to describe the beautifully varied features of the respiratory system in insects. Among those tribes especially which pass their early stages under water, the changes in form and position in these organs cannot be sufficiently admired. Several common species of gnat, the larvæ of which abound during the summer season in all our ponds and marshes, will afford a familiar illustration. When one of these is examined, a singular funnel-shaped organ, terminating in a radiated point like a star, will be perceived, forming an angle with the penultimate segment of the body. In the interior of this organ is a tube, which conveys the air to the tracheæ, and communicates with the atmosphere by means of several perforations in the centre of the star. The diverging rays of the star suspend the animal at the surface of the water, with its head downwards, till it wishes to descend. It has no sooner assumed the pupa state, than the respiratory tail disappears, and the insect (still an inhabitant of the water) then breathes through two projecting horns, each resembling a little cornucopia, which proceed from the upper part of the trunk. Ere long the skin of the pupa bursts asunder, and the perfect gnat, or winged insect, makes its appearance, with neither caudal nor thoracic appendages, but breathing by means of numerous lateral pores (the stigmata above mentioned), after the usual manner. The *rat-tailed worm* in this respect is still more extraordinary. In the larva state it breathes through a tail formed of retractile tubes, like a telescope, and capable of being extended many times the length of the body. This also terminates in a star-like process, which, when viewed in a strong light, forms a perceptible dimple on the surface of the water; and as the body of the insect lies in the mud below, the tail is contracted or extended according to the varying depth of its stagnant habitation. On assuming the pupa state, in which it is no longer an aquatic animal, the respiratory tail is cast off, and its function performed by four horns, which spring from the upper part of the thorax. It afterwards becomes one of those bee-like flies so remarkable for the rapid vibratory movement of their

[1] *Magazin der Entomologie*, iv. 410.
[2] See *Biblia Naturæ*, i. 214; and *Memoires*, iv. 245.
[3] *Vergl. Anatomie*, p. 425.
[4] *Introduction to Entomology*, iii. 505.
[5] *Cephalogenesis*, p. 57.
[6] *Physiologie*, ii. 154.
[7] *Mem. sur les Yeux composés et les Yeux lisses.*
[8] *Introd. to Ent.* vol. iv. p. 61.

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wings, by which, during calm sunshine, they are often seen suspended in the air like hawks, without any perceptible motion. In this last stage respiration is carried on by spiracles or breathing-pores.

SECT. III.—THE DORSAL VESSEL, OR SUPPOSED CIRCULATING SYSTEM, OF INSECTS.

We shall next endeavour to explain the construction and physiological uses of the organ known by the name of *dorsal vessel.*

The *primary* use of the heart of animals is the elaboration of the nutritive fluid by which the general system is strengthened and sustained; its *secondary* use is to effect the circulation of that fluid, a process by which important changes are produced in its nature or attributes. The dorsal vessel, which corresponds to the heart in insects, certainly effects the primary purpose; its performance of the secondary one is, as we shall see, a matter of greater dubiety.

When an insect is dissected with due precaution from its inferior surface, and we remove the nervous system, which first presents itself, and then the intestines and other viscera, we shall observe running along the back, a peculiar vessel, of which the most obvious powers are those of contraction and dilatation. It is of a cylindrical form, narrowed at either end, and extends from the head to the anal extremity. This constitutes the *heart*, frequently so called, of the class of insects. A closer examination shows that it is composed of two membranes, one internal and muscular, the other external and cellular, and pervaded by a close interlacement of tracheæ or air-vessels. When opened, its interior presents a transparent coagulable liquid, which dries rapidly, and then exhibits the aspect of gum, of a colour seldom deeply defined, but sometimes greenish, orange yellow, or sombre brown. Masses of fat frequently surround this vessel, and partake of the tint by which it is pervaded. If, as Marcel de Serres has noted, the *dorsal vessel* (for so this organ is often named) were a genuine heart, or centre of a circulating system, it would be necessarily open at one or other of its extremities, and would present vascular ramifications in certain points of its extent. But, according to the minute and laborious investigations of the last-named author, no such openings are observable. The same view was taken by Swammerdam; and Lyonnet, so unrivalled in his examination of the structure of insects, was foiled in his attempts to demonstrate the ramifications of the dorsal vessel. Comparetti no doubt took another view of the subject; and if the assurance of his readers was equal to his own, less suspicion would exist of the possibility of his having mistaken biliary for sanguineous vessels.

Anatomists, however, are greatly divided in opinion regarding the essential nature of this organ. It has been dissected and injected by Marcel de Serres in a variety of species; but in none could he discover its divisions or ramifications. Even when he removed it entirely from the insect, no drop of the liquid which it contained was observed to escape, which he thinks it must have done on the cutting away of open vessels during dissection, had these existed. The *beating* of this dorsal vessel was not explicable, otherwise than by the contraction of its tissue, or the movement of the fluid which it contained; and such movement was not itself conceivable except in the case of circulation, which the alleged closure and non-division of the organ forbade us to suppose. Its contractions also appeared irregular, and scarcely ever isochronic; that is, the same number of pulsations, if they may be so called, did not take place in an equal time. They varied singularly in different species. Thirty-six per minute were counted in the caterpillar of the *Pavonia Major*, eighty-two at least in grasshoppers, and a hundred and forty in one of the ground bees. While endeavouring to discover the cause of these contractions, Marcel de Serres came to the conclusion that they bore a relation, 1*st*, to the quantity of adipose tissue by which they were surrounded; 2*dly*, to the energy of the muscular fibres which were inserted on the vessel, and were the means of fixing it to the rings of the abdomen; 3*dly*, to the number of tracheæ or air conduits by which it was supplied. He was not of opinion that the nerves exercised any strongly marked influence on these contractions, although we know that special nerves are directed to the dorsal vessel. The fact, however, which he deemed the most clearly established, was the influential action of the muscles. When any of these were removed, the pulsations became less frequent,—on a farther removal they still diminished; and when the muscles were almost all withdrawn, the pulsations ceased. The appropriate function of this disputed organ, according to the last-named author, is the secretion of fat. Baron Cuvier also denies to it the character of a genuine heart.

Meckel and Herold, on the other hand, regard the dorsal vessel as a heart, and they conceive that the use of its movement is to agitate the fluid contained in the cavity of the insect's body; but they do not admit the existence of posterior or anterior openings for the reception or rejection of that fluid. It is long since Lyonnet informed us that it contained a gummy matter of an orange colour; and some recent observations have led Latreille to admit the existence of certain very minute accessory vessels. In addition, however, to the fact that this circulation must be extremely partial, insects would still greatly differ in that respect from the Crustacea, inasmuch as the blood does not return to the heart. Herold is of opinion that the triangular muscles of the dorsal vessel serve for its dilatation, while the systole movements are effected by the muscular fibres, which form the proper tunic. Straus is also of opinion that the dorsal vessel is the true heart in the class of insects, and that it serves, as in the higher animals, as the motive organ of the blood, which, however, instead of being contained in vessels, permeates in the general cavity of the body. According to his views, it terminates anteriorly by a single unramified artery, which conveys the blood to the head, where it pours it out, and from whence it returns again to the abdomen, to re-enter the dorsal vessel. He thus limits the circulating system of insects to a single artery without branches (there are not any veins); and he combats the sentiments of Herold regarding the muscular nature of the wings of the heart, which, he maintains, are only simple fibrous ligaments, by which it is maintained in its proper place. The heart itself, that is, the abdominal portion of the vessel, he describes as divided interiorly into eight successive chambers (as in the common cockchafer, *Melolontha vulgaris*), separated from each other by two convergent valvules, which permit the transmission of the blood or circulating fluid from behind forwards, and from one chamber to another, up to the artery which conducts it to the head, but prevent its retrograde motion. Towards the lateral and anterior portion of each chamber are two transverse fissures, which communicate with the abdominal cavity, and through which the blood contained in the latter enters the heart. Each of these apertures is provided internally with a little semicircular valve, which presses on it during the systole of the organ. When the posterior chamber dilates, the fluid contained in the abdominal cavity penetrates into it by the transverse fissures, called *auriculo-ventriculaires* by M. Straus. When the chamber contracts, the blood, unable to return into the abdominal cavity, forces the *inter*-ventricular valve, and passes into the second chamber, which dilates to receive it,

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along with an additional quantity which enters by the true auriculo-ventricular openings. The second chamber then contracts in a similar manner, and forces the fluid into the third, which at the same time also receives a supply from the lateral openings; and thus the blood is forced from one chamber to another by successive contractions, till it reaches the artery. These are said to constitute the movements so distinctly perceptible through the dorsal skin of many caterpillars.

Mr Bowerbank has recently published some observations on the circulation of the blood in insects.[1] The instance detailed was that of the larva of an Ephemera (*E. marginata*). In fixing the insect for examination (under water), especial care must be taken not to compress the body, which impedes or interrupts the circulation of the lateral vessels, and that of the tail, legs, and antennæ. When the larva is fixed, with its dorsal aspect towards the observer, a truly beautiful sight is said to present itself. The blood, abounding in flattened oat-shaped particles, will be seen circulating in every part of the body, not in a continuous stream, but at regular points, in accordance with the pulsations of the great dorsal vessel. The latter, which is of great comparative magnitude, extends nearly the whole length of the body, and is furnished at regular intervals with double valves, nearly equal in amount to the segments of the body. Both above and below each of these sets of valves there is a pair of irregular-looking appendages, which are probably nervous ganglions, auxiliary to the motions of the vessel, but so extremely translucent as to be scarcely definable in their form, even through the medium of the highest power which we can apply. The action of the valves is singularly interesting. While in their greatest state of collapse, the point of the lower valve is seen closely compressed within the upper one. At the commencement of the expansion of the artery, the blood is seen flowing in from the lateral aperture, and at the same time the stream in the artery commences its ascent. When it has nearly attained its greatest state of expansion, the sides of the lower valve are forced upwards by the increased flow of the blood from the section below the valve, the lateral openings are closed, and the main current of the blood is projected through the two valves. The structure of the upper valve appears to consist of a duplication inwards and upwards of the inner coat of the artery; that of the under, of a contraction and projection of the like parts of a portion of the artery beneath, so as to come within the grasp of the lower part of the valve above it. The exterior portion or continuation of the artery is perceptible in the form of an exceedingly fine and transparent membrane. The so-called blood does not appear to be confined within any specific vessels prior to its entering the lateral openings just mentioned, because, as soon as they expand, the particles are seen converging towards them. The whole of the fluid received throughout the course of the dorsal vessel is conveyed to the extremity of the anterior part of the body, where the vessel makes a curve inwards, and is lost to view. To all appearance the main current of the blood is now discharged into the cavity of the body, as it is seen pursuing its course downwards in a wide-spreading stream on each side, and beneath the dorsal vessel. As it descends, portions are again absorbed by the valves of the large vessel, while at the same time smaller vessels pass down each side of the body, and convey another portion of blood to the lower extremity. These lesser vessels have perceptible boundaries, and are certainly not portions of the great abdominal cavity. They communicate at each junction of the segments of the body with that cavity, as a part of the fluid they convey is discharged at those points, to supply the place of what is absorbed by the valves of the dorsal vessel, into the lower end of which they empty their contents. In the caudal extremity the ascending and descending vessels are seen, like vein and artery, to accompany each other, and at the same moment that the fluid passes up the one with the usual pulsatory motion, it descends the other. There is, however, no perceptible pulsation of these minuter vessels themselves, and the motion of their fluids therefore results from the action of the great dorsal heart.

"Next to the larvæ of the Ephemera marginata," Mr Bowerbank observes, "the larvæ of Agrion afford the best view of the blood and its circulation. In all the species of these larvæ I have yet examined, I have found it as nearly similar as possible in appearance to that which we observe in the Ephemera, and in some instances it has afforded even more satisfactory results. The head of this larva is much more transparent than that of the larva of the Ephemera; we therefore have a better view of the circulation of the blood in the head of this insect than can possibly be obtained in the other. In this object the blood is seen rushing like a beautiful intermittent fountain towards the mouth, and dividing right and left into two jets, a portion of each of which flows within a given boundary past the back of the eye, whilst the remainder winds its way through other channels, deep in the side of the head, and returns again into the body. The antennæ of this insect also afford another beautiful instance of the circulation being carried forward within well-defined vessels. They are each composed of six joints, up four of which the blood is seen to take its course; and turning round the extremity of the fourth joint, it returns by a distinct vessel into the head. In the leg, likewise, the circulating fluid and its vessels are clearly and distinctly to be traced, even to the very extremity of the tarsus, where, as in the antennæ, the particles of the blood are seen to descend on the one side of the leg, and, turning the extreme point, to return up the contrary side to the one by which they come down. I regret much that I have not yet had an opportunity of examining the Ephemera in its perfect state; but in two species of Culex, one of which was first observed and brought to me by my friend Mr Tulley, I have seen the great dorsal vessel performing its functions in a manner similar in every respect to its appearance in the larvæ of Ephemera, Agrion, &c. &c.; but, from the body of the fly being more opaque than that of the larvæ, and nearly covered with its striated scales, neither the valves nor the particles of the blood could be detected. On another occasion, after having carefully cleared the wings of Phlogophora meticulosa of their coloured scales, both Mr Samouelle and myself clearly saw a fluid pass down the side of one of the principal ribs of the wing. We may therefore, I think, fairly conclude, that the circulation is carried forward in the perfect insect as well as in the larva, although, perhaps, not with so much vigour as when young and growing."[2]

The writer whose observations we have just quoted, inclines to the opinion that a much greater portion of the circulation than we can clearly define is carried on within special vessels, as the blood may be frequently seen flowing in curved and other lines, as if confined within very narrow limits. These streams, however, are generally so deeply seated amidst the muscles and intestines as totally to prevent their boundaries from being clearly seen. The blood itself is in fact a perfectly colourless and transparent fluid, rendered visible only by its containing a number of oat-shaped particles; and even the great dorsal vessel can-

[1] *Entomological Magazine*, No. III. p. 239.

[2] *Ibid.* p. 242.

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not be seen distinctly but by means of a glass of great power, and, under the most favourable circumstances, exhibits defined limits with certainty only when in motion. A singular coincidence is observable between the flattened particles of the blood of insects, and the circular double concave plates in that of man, namely, that the former, in common with the latter, assume a globular form immediately on coming into contact with water.[1]

The reader will be able to judge, from the preceding notices, of the diversified opinions still entertained regarding the circulation of the blood in insects. We shall conclude with a short account of Dr Carus's observations, which many consider as the first of a satisfactory and conclusive nature on the subject. Mr Spence, the accomplished coadjutor of Mr Kirby, having had the advantage, at a pretty recent period, of witnessing some of the most striking facts on which the Dresden physician rests his views, transmitted an account of them to an English periodical. "The first insect," he observes, "to which Dr Carus directed my attention was the larva of *Ephemera vulgata* (or an allied species), in which, near to the branchiæ, and parallel with each side of the body, was very distinctly visible a constant current, towards the tail, of oblong globules, swimming in a transparent fluid, propelled with a regular pulsating motion; and in cutting the body of the larva across, near the tail, these globules were most plainly seen pushed out of the divided vessels in a distinct mass, which increased at each pulsation. I cannot express the pleasure which it gave me to see thus clearly this ocular demonstration of one of the most important physiological discoveries of modern times; and my gratification was heightened by the next object which Dr Carus placed before his microscope, viz. a specimen of *Semblis viridis*, in which precisely the same phenomena, but if possible more clearly, were seen in the nervures of the wings, and in the antennæ, in both which the constant current of globules was most apparent; and in the former, the sudden turning of these globules at the apex of the wing, out of the exterior nervure, into a central one, with which it joins and forms an acute angle, was equally curious and striking. On cutting off the end of the antennæ, precisely the same emission of globules (which soon assume a greenish tint) took place as in the former case, forming a mass which was increased with a sudden gush at each pulsation."[2] The chief point to be attended to in the manipulation of these microscopic experiments, is to place the specimens on the slip of glass, in a drop of pretty thick gum water, which confines their too agile movements, without affecting the transparency of the medium.

SECT. IV.—OF THE ADIPOSE TISSUE OF INSECTS.

Insects are abundantly supplied with an adipose substance or fatty matter, which may be mentioned in this place with the more propriety, as many consider it a secretion from the dorsal vessel. It is spread over the viscera and in the splanchnic cavities; and although its aspect varies, it seems to consist essentially of membranous woofs, in some cases divided in shreds, in others spread over the intestines and against the sides of the abdomen, and containing pouches filled with a homogeneous pulpy matter, sometimes in an oily condition, and offering all the characters of grease. Much more of it is observable among larvæ than in perfect insects, and this observation leads us to a knowledge of its use. It is particularly plentiful just before an insect is about to undergo its metamorphosis; and as it almost entirely disappears on the completion of those signal changes, we naturally conclude that it has served in the production or development of the newly acquired organs. This is rendered the more probable when we consider that, during the intermediate or nympha state, the insect abstains from food, and is therefore necessarily dependent on some internal reservoir. It is analogous, in fact, to the store of fat which is known to pervade the system of hybernating animals before they consign themselves to their winter sleep.

In regard to the nutrition of insects, our opinions must be in a measure regulated by the sentiments which we may adopt as to the functional uses of the dorsal vessel. We need scarcely observe, that in all the higher animals, and in most of the invertebrated tribes, nutrition is effected through the medium of the blood, which, propelled by the heart, circulates through the entire system, and reaches every organ, after having been submitted to the action of the air in lungs or gills. Cuvier thinks it is carried on among insects by imbibition. The alimentary canal elaborates a fluid which transudes through its coats, and flows into the cavity of the body. There the various organs, such as the muscles, the nerves, and many secreting vessels, absorb from that fluid nutriment, whatever molecules are best adapted to their purposes. Those who look upon the dorsal vessel as a true heart, which dispenses a circulating fluid to the remotest ramifications of the wings and tarsi, will place less confidence in this particular view. However, it is certain that the secreting vessels are characterized by a structure entirely appropriate to the functions which we have just assigned them, their surface being obviously furnished with numerous pores or small absorbent mouths.

SECT. V.—THE DIGESTIVE SYSTEM OF INSECTS.

The digestive system in insects naturally forms the next subject of consideration. The earliest, most general, and perhaps the only indispensable function of animal life, is that of nutrition. But its materials are so different, and their modes of reception so various, that the exercise of this function by no means necessitates the existence of a mouth, a stomach, or an alimentary canal; for an increase of parts may be effected even through the medium of imponderable or elastic fluids, and by imperceptible and superficial pores.[3] The digestive organs of insects are however in general rather complicated, and a great variety of parts are brought into action. The more external portions, or those of the mouth, have been already described. We shall therefore at present confine our observations to the different portions of the *intestinal canal*, and the *biliary* and *salivary vessels*.

It is natural to suppose that, in a class so extensive and varied as that with which we are now engaged, a corresponding diversity must exist in the form, development, and number of the parts which constitute the intestinal canal. It is always, however, so far tubular, and open at either end; but in some it is straight and of the length of the body; in others it is bent and longer than the body; while in many it is tortuous, or twisted on itself in numerous convolutions, and consequently of great extent. In general, its length corresponds in a certain measure with the nature

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[1] *Entomological Magazine*, p. 244.

[2] *Magazine of Natural History*, vol. iii. p. 46. See also the German memoir by Dr Carus on the circulation of the larvæ of neuropterous insects (Leipsig, 1827). The English reader may consult Mr Gore's translation of Carus's *Introduction to Comparative Anatomy*, appendix to vol. ii. p. 392.

[3] Vol. iii. of this work, p. 183.

of the aliments; such insects as feed on vegetable matters having a longer, and such as feed on animal substances a shorter canal. In some it is of equal diameter throughout; in others the breadth of special portions varies; and there are many dilatations and restrictions, known by various names. It even differs greatly in the same species, according as the individual exists in the larva or imago state.

The texture of the intestinal canal in insects is not the same in all parts of its extent; but on a careful examination it is found to exhibit throughout three tunics, more or less distinctly marked. Of these, the first is external, with a membranous aspect; the second is of course intermediate and muscular, with its fibres diversely directed; the third is internal and mucous. In its more complicated state it exhibits the following parts: 1*st*, a *pharynx*; 2*d*, an *œsophagus*; 3*d*, a *crop*; 4*th*, a *gizzard*; 5*th*, a *chylific ventricle*; 6*th*, *intestines*, which may be considered in subdivision as the small intestines, the great intestine or cæcum, and the rectum. The following may be regarded as the usual process of transmission. The mouth, having seized and chewed the food, transmits it to the pharynx, into which salivary vessels sometimes open. It then passes into the œsophagus (of which the muscular nature occasionally produces by its action a peculiar impression), and is next transmitted to the crop, which converts it into a homogeneous pulp. This is introduced into the gizzard, of which the sides, being armed with teeth, complete its trituration. In the form of a kind of paste it is now received by the chylific ventricle, where it undergoes the action of the bile, is converted into chyle, and thus supplies the nutritive fluid, which, passing through the coats of the ventricle, spreads over the splanchnic cavity, and pervades the whole of the organs. The residue is received by the small intestine, then by the great intestine, in which it remains for some time, and finally by the rectum.

The *pharynx*, which is sometimes rather difficult to distinguish as a distinct feature, is placed at the bottom of the mouth, and may be regarded as an anterior dilatation of the œsophagus. Two pieces, very apparent in certain Hymenoptera, called the *epipharynx* and the *hypopharynx*, seem to restrict and protect its entrance.

The *œsophagus* is a conduit varying in length, which traverses the prothorax, and sometimes extends beyond it; but it is occasionally so short as scarcely to pass beyond the region of the head. Its structure is musculo-membranous, and it opens into the crop, or, if that part is wanting, into the gizzard, or, if the latter is also absent, into the chylific ventricle. It is around the origin of the œsophagus that the nervous system, as formerly described, constitutes a ring, by sending forth two branches which unite on the inferior face of the body.

The *crop*, which is by some called the stomach, is essentially nothing more than a dilatation of the œsophagus. It is often difficult to detect, is sometimes entirely wanting, and may be observed to vary greatly even in two individuals of the same species. Exteriorly it does not differ much from the gizzard, but its interior never presents those corneous pieces which in the latter serve the purposes of trituration. Its position bears some analogy to that of the crop of birds, from which circumstance it has probably derived its name. Its texture is simply membranous, or slightly muscular when its development is considerable, and in that case it is not rare to observe certain folds or fleshy columns and deeper lines, which give it something of a ribbed appearance. These folds, prolonged in the interior, frequently constitute a kind of valve. It is in this crop that bees contain their honey prior to their disgorging it, and it likewise serves as the reservoir of that black and often fetid fluid which many insects allow to flow from their mouths when they are seized. The form of the crop differs in the various species; and even in individuals of the same species, according to its state of repletion or vacuity, it assumes an ovoid, rounded, or pear-shaped appearance. In some orders of insects it is greatly developed, and very muscular; and in certain cases, instead of lying in the same direction with the intestinal canal, it forms with it an angle more or less acute, thus constituting a lateral pouch varying in extent and form.

The *gizzard* follows the crop. Its existence is not constant, and its essential character consists in its singular internal structure, which is furnished with moveable portions of a horny texture, provided with ridges or bristles pointed in all directions, in the form of combs or brushes. The principal portions are more or less numerous, and form by their union a kind of valvule at the orifice of the chylific ventricle, into which they permit nothing to enter but what has been previously reduced to a state of tenuity. This very singular triturating machine, as we may call it, exists among both the herbivorous and carnivorous kinds. It recalls to mind the aspect of the stomach among the crustaceous tribes. Externally it greatly resembles the crop, and indeed can scarcely be distinguished from it otherwise than by its internal structure.

The *chylific ventricle*, which corresponds to the part named *duodenum* by Marcel de Serres, and *stomach* by Ramdhor, is a very constant organ among insects, although its form and character are extremely various. It is here that the pulpy food, mixed with specially elaborated fluids, is converted into chyle. One of its most constant characters is the insertion on a kind of circular pad more or less developed, of at least one extremity of the biliary vessels. Its texture is soft and delicate, and capable of varying its capacity by extension. Its form is generally cylindrical, although it sometimes undergoes dilatations and restrictions in its course. In some rare instances, detailed by M. Dufour, it is bilobed or bifurcated at its commencement, the preceding part of the alimentary canal being inserted in the angle of the furcation. It presents several other occasional and very curious characters, but it is in general straight, and but rarely exhibits a limited number of convolutions. It is not garnished interiorly with triturating organs, either muscular or corneous; but it is furnished with a valvule at the point of union with the intestine. One of its most curious characters consists in its being sometimes villous on the surface, that is, covered by a quantity of little tubes, named *villosities* by Cuvier, and *papillæ* by Dufour. These are a species of tubes or purses, somewhat resembling the fingers of a glove, and opening into the ventricle. Their functional uses are differently construed by physiologists. Cuvier inclines to think that they draw from the abdominal cavity a gastric fluid, which they pour into the ventricle to aid digestion. Marcel de Serres partakes of the same opinion, and regards these papillæ as the superior hepatic vessels. Dufour, however, does not consider them as analogous to the biliary vessels, but as culs-de-sac, which receive the alimentary fluid, and, after its conversion into chyle, transmit it to the abdominal cavity. That able anatomist has recognised in their interior a brownish matter, quite analogous to what is contained in the ventricle itself. They do not differ greatly as to form, but a great variation occurs in regard to number and disposition. Sometimes they exist in great numbers throughout the whole extent of the ventricle, sometimes they are fewer in number, and confined to a limited portion. Insects belonging to the orthopterous order have but few of these papillæ, but they are greatly developed, and inserted on the anterior part. In other instances the papillæ are entirely absent; and the ventricle is then smooth, or occasionally exhibits depressed lines, which divide it transversely into so many little bands. The presence of

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these papillæ cannot be regarded as a constant character in any group, for we find them absent or present in different insects of the same family, without any known or assignable cause. They occur indiscriminately among carnivorous and herbivorous species; but it is among the coleopterous tribes that they show themselves most frequently, and under the most characteristic forms.

The *intestines* constitute an extended portion of the canal. They receive the alimentary matters after they have been digested in the chylific ventricle, and extract by their action whatever nutriment remains. Their absorbent powers, however, as alimentary organs, are probably confined chiefly to their upper portion. They consist of a *small intestine*, a *great intestine*, and a *rectum*. The small intestine of course proceeds from the ventricle, and is in general narrow, with an equal diameter throughout, although it is sometimes swollen or pursed in the course of its extent. It is of various length, and makes numerous circumvolutions in the interior of the abdomen, after which it borders with the great intestine. The latter, called also the *cæcum*, consists of a swelling or enlargement, usually ovoid and smooth, but not unfrequently also covered by plaits and little muscular rib-like bands, more or less projecting. It is dilatable, and in some cases is swollen beyond measure, especially among certain aquatic tribes, such as the *Dytisci*. In these, as detected by the skilful eye of M. Dufour, the cæcum is no longer placed in the direction of the intestinal canal, but is thrown to one side, and furnished with a vermicular appendix, spirally twisted. It becomes inflated with air at the will of the insect, and thus seems to act the part of a swimming bladder. Other modifications of this organ have likewise been observed, into the detail of which we shall not here enter. The rectum is a muscular tube, in general of no great extent.

We shall next devote a few lines to the *biliary vessels*. That peculiar fluid called bile seems equally indispensable to the digestion of insects as to that of the higher animals, but the organ which secretes it is very different. In the former class it has no longer the appearance of a gland, but consists of more or less numerous vessels, of variable length, fixed for the most part by a single extremity, but not unfrequently by both ends, to the intestinal canal, and floating as it were in the abdominal cavity. These vessels are often rolled on themselves, and interlaced by numerous tracheæ and slender nervous filaments. They are never wanting in insects, and they exist equally in the larva state as in the perfect condition. They are delicate tubes, composed of a thin and pellucid membrane, on which certain transverse foldings produce a somewhat varicose appearance. They contain a liquid, sometimes limpid and colourless, but usually varying from yellow to brown. It is bitter, and exhibits all the characteristics of bile. The vessels themselves vary in amount from two, four, six, to an almost countless number. Their mode of insertion exhibits some remarkable variations, which however may be reduced to two great divisions: 1*st*, where the insertion takes place upon the ventricle alone; 2*d*, where it takes place upon the cæcum likewise. The first of these divisions offers two classes; sometimes the vessels are inserted only by one extremity, while the other is free or floating; sometimes they are fixed by both ends, and form so many arches. In the latter case they are few in number, and each arch may be regarded either as a vessel strongly curved towards the two points of insertion, or may be looked upon as composed of two vessels exactly anastomosed at their extremities. A coleopterous insect belonging to the genus *Donacia*, described by M. Dufour, was observed to possess a ventricle provided at once with arched vessels and with such as were free at their extremity. Such a combination connects, as it were, the characters which principally distinguish the first great division. The second great division above alluded to never presents us with any vessels that are free or unattached at one extremity. They form a complete arch from the ventricle to the cæcum, and scarcely present any particular character, except that their number is always restricted. The insertions on the ventricle are always more distinct than those on the cæcum; the latter being rarely isolated, but usually uniting into a smaller number of common branches, and sometimes into one.

The *salivary vessels* consist of floating tubes, which open about the pharynx, and furnish a liquid to assist in deglutition. They are sometimes wanting or imperceptible, and are more general, as well as more highly developed, among the suctorial than the masticating tribes. The receptacles which supply the silk used by spinning caterpillars, are by many regarded as analogous to salivary glands, as are likewise the organs which furnish the venomous fluid in the mouths of Scolopendræ.[1]

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CHAPTER IV.

THE METAMORPHOSES OF INSECTS.

As frequent reference is made, in the course of this treatise, to the metamorphoses of insects, we shall here endeavour to explain in what these essentially consist. "Were a naturalist," observe Messrs Kirby and Spence, "to announce to the world the discovery of an animal, which for the first five years of its life existed in the form of a serpent; which then penetrating into the earth, and weaving a shroud of pure silk of the finest texture, contracted itself within this covering into a body without external mouth or limbs, and resembling more than any thing else an Egyptian mummy; and which, lastly, after remaining in this state without food and without motion for three years longer, should at the end of that period burst its silken cerements, struggle through its earthy covering, and start into day a winged bird,—what think you would be the sensation excited by this strange piece of intelligence?" Yet the difference which exists between the sometimes repulsive aspect of a creeping caterpillar, and the consummate beauty of the gorgeous butterfly to which it gives existence, is as remarkable as any supposable change from one form of animal life to another.

Although the ancients appear to have been aware that many insects, such as butterflies, bees, and beetles, proceeded from eggs, and underwent those changes which we name metamorphosis; yet, very shortly before the time of Redi, Swammerdam, Malpighi, and Leeuwenhoeck, to whom we owe so much of our present knowledge, Mouffet, who has been called the father of entomology, mistook the aquatic larvæ of Libellulæ for creatures entirely distinct from the perfect insects, and named them *Water Locusts!* The error was excusable, and has no doubt often been repeated in corresponding cases; for how many are ignorant, even at the present day, that the slender red-coloured wriggling worm, which is so often seen in collections of rain water,

[1] Whoever inclines to enter fully into these subjects, will find in Messrs Kirby and Spence's *Introduction to Entomology*, not only a very ample and able account of the structure and functions of the various organs of insects, but also such references to the best informed writers, as will unfold a wide field for further study and reflection. See also *Entomologia Edinensis* (Introduction); the article *Insectes* in the *Dict. Classique d'Histoire Naturelle*, t. viii.; and M. Dufour's papers on Insect Anatomy, in the *Annales des Sciences Nat.*

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is the larva state of a clear-winged and elegantly formed fly, furnished with feathered antennæ and long slender limbs, the *Chironomus plumosus?* How entirely dissimilar is the hairy caterpillar, which we frequently observe crossing our foot-path in country lanes, from the richly attired tiger-moth which it eventually becomes? Many examples of a similar nature will probably occur even to the least instructed reader.

The word metamorphosis seems to have passed originally from a mythological meaning to a term in natural science. We had deemed it an ancient phrase, till we were informed by Mr Kirby that *μεταμορφοω*, and its derivative *μεταμορφωσις*, are not extant in any Greek writer before the date of the New Testament. They are used to express any *external* change of form or colour, and metaphorically any *inward* change and progressive improvement of the mind. The word metamorphosis, as applied to insects, is in fact synonymous with the more familiar term *transformation*, although, speaking strictly in relation to physiology, the changes indicated by these expressions should rather be regarded as a series of developments.

All insects proceed from eggs either previously deposited by the female parent, or, as in the case of the so-called viviporous (strictly ovo-viviporous) kinds, hatched within the body of the mother. Their first active condition is that of larva, which, according to the views of Swammerdam, contains within itself the germ of the future perfect insect, and those various envelopes, each of which, successively developed, becomes external and apparent by the casting off of that by which it was preceded.

Thus a caterpillar may be viewed, not as a simple, but a compound creature, containing within it the germ of the future butterfly, inclosed in what will become the case of the pupa, which is itself included in several more envelopes or skins, each of which becomes external in its turn. As the larva (so called from the very circumstance of its containing the *imago*, or perfect insect, shut up as it were in a *mask*) increases in dimensions, the various parts expand, and are thrown off, until at length the completed and more beautiful form is displayed in all its lustre. Swammerdam, in fact, discovered, by careful dissection, not only the skins of the larva and pupa incased within each other, but within these again the very butterfly itself, with its organs all complete, though nearly in a fluid state.[1]

Of the same fact, Mr Kirby states, any one may convince himself, without the skill of the great Dutch observer, merely by plunging into vinegar or spirit of wine a caterpillar about to assume the pupa state, and allowing it to remain there for a few days till it gains consistency of parts; or by boiling it for a few minutes in water. A very rough dissection will then enable the student to detect the future butterfly,—the wings being rolled up into a sort of cord, and lodged between the first and second segments, the antennæ and trunk coiled up in front of the head, and the legs, though very dissimilar in form, actually sheathed in those of the caterpillar. Malpighi, moreover, discovered the eggs of the future moth in the chrysalis of a silk-worm only a few days old;[2] and Réaumur those of *Bombyx dispar*, even in the caterpillar, seven or eight days prior to its change into the pupa state.[3]

According, however, to the more recent doctrines promulgated by Dr Herold, the successive skins of the caterpillar, the case of the pupa, and the members of the perfect insect (except the sexual distinctions, which he perceived even in the newly excluded larvæ), do not pre-exist as germs, but are formed successively from the *rete mucosum*, which itself is formed anew upon every change of skin, from what he denominates the blood, or the chyle after it has passed through the pores of the intestinal canal into the general cavity of the body, where being oxygenated by the air-vessels, it performs the nutritive functions of blood.[4] These proceedings, as usual, are attributed to a *vis formatrix*, a term of most convenient application where the mysterious workings of nature are but dimly seen or vaguely understood. But whatever may be the mode or principle of development, we know that insects exist in the four following states,—the *egg*, the *larva*, the *pupa*, and the *imago* or perfect condition.

The first stage of *life*, properly so called, is that of larva, in which existence is usually more prolonged than in any other, and in which the insect does nothing but eat voraciously, and increase rapidly, with intervals of repose occasioned by repletion. In this state it is entirely sterile. In the course, and towards the termination, of the larva state, that peculiar internal secretion the caul, epiploon, or fatty matter, formerly mentioned, is observed to increase, and the insect then assumes the pupa state, which is usually one of inaction and apparent torpidity. Ere long the skin of the pupa bursts asunder, or the wings and members become sufficiently developed for active exercise, and the insect assumes the perfect state, as exemplified in bees, beetles, and butterflies, all of which proceed from a worm-like larva. In this condition they are usually less voracious, their principal object and occupation being the preservation or continuance of their kind.

All insects, however, do not pass through these transformations. Most of the apterous kinds issue from the egg in a form very similar to that which they maintain throughout their after lives; from which circumstance Linnæus and others have bestowed the name of *complete pupæ* on their intermediate state, when such is recognisable. Even those that are subjected to the signal changes above described, differ considerably in the nature and degree of metamorphosis to which they are subjected. Many of the winged kinds experience no other change than the accession of the organs of flight. Their larvæ resemble the perfect insect, with the exception of the want of wings. Their pupæ, known as *semi-complete*, merely differ from the larvæ by exhibiting the rudiments of those organs the eventual development of which produces the completion of the perfect insect. Such are the grasshopper and locust tribes, in which the pupæ continue to exercise their locomotive powers and ordinary vital functions. Those insects which undergo a more entire metamorphosis are changed from larvæ into motionless and inert pupæ, and this mode of transformation presents different gradations. The pupæ, or nymphs as they are often called, of the Coleoptera and several other orders, exhibit their external members in close approximation to the body, but *free* or uncovered by any general envelope; we name them *incomplete*. But among the Lepidoptera, such as butterflies and moths, an elastic but firm and sufficiently solid skin or integument is moulded over the entire body and its various members, and only shows the form and outline of the latter visibly impressed upon its surface. These were called *pupæ obtectæ* by Linnæus. Dipterous flies, again, are covered in the pupa state by small simple cases, or egg-like shells, usually regarded as the skin of the larva, through which the form and proportions of the parts are in no way discernible. These were termed *pupæ coarctatæ* by the great Swedish naturalist.

When, however, we make use of the term *metamor-*

[1] Hill's *Swammerdam*, ii. 24.

[2] *De Bombyce*, 29.

[3] *Memoires*, i. 359.

[4] *Entwicklungsgeschichte der Schmetterlinge.*

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phosis, in relation to the different states of insects, another meaning is apt to result from the application of the words complete, semi-complete, and other adjective phrases,—for the less complete the pupa, the more complete the metamorphosis. Some confusion, we think, has arisen from this circumstance,—at least we have ourselves been occasionally puzzled by the contrariety of opinion expressed upon the subject even by the " master spirits" of entomology. Thus, Latreille observes, " Les Coléoptères subissent une métamorphose complète,"[1] while Mr Kirby has it " Metamorphosis *incomplete*,"[2] and the same form of expression is used by Mr Macleay.[3]

However this may be, our entire range of natural knowledge presents us with nothing comparable in singularity or beauty with the phenomena of metamorphosis. No wonder that the mystical sages of Egypt, and the refined philosophers of Greece, were so entranced or delighted with what they saw and fancied, as to found upon these changes many of the fondest fables which now pervade our classical literature. "Psyche," says Dr Nares, " means in Greek the human soul; and it means also a butterfly, of which apparently strange double sense the undoubted reason is, that a butterfly was a very ancient symbol of the soul. From the prevalence of this symbol, and the consequent coincidence of the names, it happened that the Greek sculptors frequently represented Psyche as subject to Cupid in the shape of a butterfly; and that even when she appears in their works under the human form, we find her decorated with the light and filmy wings of that gay insect."[4] Swammerdam himself, although his observations tended to prove that the analogy between the metamorphosis of a butterfly and the resurrection of the body, or second life of the human soul, was not so close as had been imagined, is yet of opinion that the process is so remarkable as to paint and exemplify that resurrection before our eyes.[5] " To see, indeed, a caterpillar crawling upon the earth, sustained by the most ordinary kinds of food, which, when it has existed a few weeks or months under this humble form, its appointed work being finished, passes into an intermediate state of seeming death, when it is wound up in a kind of shroud and incased in a coffin, and is most commonly buried under the earth (though sometimes its sepulchre is in the water, and at others in various substances in the air); and, after this creature and others of its tribe have remained their destined time in this deathlike state, to behold earth, air, and water, give up their several prisoners; to survey them, when, called by the warmth of the solar beam, they burst from their sepulchres, cast off their cerements, from this state of torpid inactivity come forth as a bride out of her chamber,—to survey them, I say, arrayed in their nuptial glory, prepared to enjoy a new and more exalted condition of life, in which all their powers are developed, and they are arrived at the perfection of their nature; when, no longer confined to the earth, they can traverse the fields of air, their food is the nectar of flowers, and love begins his blissful reign;—who that witnesses this interesting scene can help seeing in it a lively representation of man in his threefold state of existence, and more especially of that happy day, when, at the call of the great sun of righteousness, all that are in their graves shall come forth, the sea shall give up her dead, and death being swallowed up of life, the nations of the blessed shall live and love to the ages of eternity?

" But although the analogy between the different states of insects and those of the body of man is only general, yet it is much more complete with respect to his soul. He first appears in this frail body—a child of earth, a crawling worm, his soul being in a course of training and preparation for a more perfect and glorious existence. When it has finished this course it casts off this vile body, and goes into a hidden state of being in Hades, where it rests from its works, and is prepared for its final consummation. The time for this being arrived, it comes forth clothed with a glorious body, not like its former though germinating from it, for though ' it was sown an animal body, it shall be raised a spiritual body,' endowed with augmented powers, faculties, and privileges, commensurate to its new and happy state. And here the parallel holds perfectly between the insect and the man. The butterfly, the representative of the soul, is prepared in the *larva* for its future state of glory; and if it be not destroyed by the ichneumons and other enemies to which it is exposed, symbolical of the vices that destroy the spiritual life of the soul, it will come to its state of repose in the *pupa*, which is its Hades; and at length, when it assumes the *imago*, break forth with new powers and beauty to its final glory and the reign of love."[6]

Swammerdam, to whom we owe the earliest philosophical examination of the subject, divides the phenomena of metamorphosis into four classes. In the first, in which the changes are the least varied or remarkable, he includes apterous insects commonly so called, most of which we now name Myriapoda, and the metamorphosis of which consists in gaining additional segments and pairs of feet; also Arachnides and Crustacea, which are for the most part characterized by simple renewals of their envelope. In the second class he places such insects as are born with six feet, but have their wings concealed or inclosed in a sheath during a rudimentary period, such as Orthoptera, Hemiptera, and many Neuroptera. In the third class are included those insects which exhibit three distinct conditions; they compose two subdivisions. The first comprises those insects of which the second state, called nymph or semi-nymph, exhibits either the appearance of feet and wings, or the reality of these organs. They are not reduced to that state of utter lethargy or apparent death which some present, and they include the remainder of the Neuroptera, the Hymenoptera, and the Coleoptera. The other subdivision contains the Lepidoptera, of which the larvæ, commonly called caterpillars, are subject to several preparatory changes of their coat, and are finally converted into chrysalids, through the coriaceous skin of which the interior parts are perceptible, but which externally exhibit neither wings nor legs, nor any other members.

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[1] *Règne Animal*, t. iv. p. 354.

[2] *Introduction to Entomology*, vol. iv. p. 369.

[3] *Horæ Ent.* p. 440. The confusion above referred to may perhaps have arisen from certain adjective phrases having been at times applied indifferently, either to the state of pupa or the phenomena of transformation, which in most cases causes a contradiction in terms. In Orthoptera, of which the pupa is semi-complete, the metamorphosis may bear the same designation; but in the other orders the double application of any of the adjective terms leads to inaccurate ideas. Thus, in Coleoptera, the pupæ are *semi-complete;* but there is surely a total transformation, that is, a *complete* metamorphosis, when we compare together the larva and the perfect insect. So also in Lepidoptera, the pupa is obtected; in Diptera, coarctate; and consequently the metamorphosis must be *complete* in both. Now Mr Kirby makes use of the phrase " metamorphosis obtected" in regard to the former, and " metamorphosis coarctate" in relation to the latter,—terms which we have been in the practice of applying to the pupa state of these orders, but not to the general transformations. The same admirable author, in defining apterous insects, states the metamorphosis to be *complete.* We would rather say that they undergo *no* metamorphosis at all,—for which very reason, each particular state, or rather period, of the insect, is itself complete from youth to age. The less complete the pupa, the more complete the metamorphosis, and *vice versa.*

[4] *Essays*, i. 101.

[5] Hill's Translation of the *Biblia Naturæ*, i. 187.

[6] *Introduc. to Ent.* vol. i. p. 75.

Metamorphoses. Finally, in the fourth class are included all those insects which on their exclusion from the egg exist as vermiform apodal larvæ, are provided at most with six feet, and are converted into nymphs without a change of envelope, so that their skin merely hardens over the intermediate state of the insect, which ere long issues winged. Such are the dipterous tribes.

These views and combinations have been somewhat modified in later years, by Réaumur, Linnæus, Fabricius, Huber, Dutrochet, Savigny, Marcel de Serres, Latreille, and others who have devoted themselves to the investigation of metamorphoses. Those phenomena have consequently been classed as incomplete or partial by which the aspect of the insect is merely modified, and as complete or total by which it is entirely changed. In all, the interior changes may be said to command the exterior, that is, the latter are consequent on the former. In numerous species, not less than three of the principal organic systems, viz. the *nervous*, the *nutritive*, and the *respiratory*, undergo important modifications, and we may easily conceive how strongly the instinctive habits of the individual must be thereby affected. The alterations in the nervous system especially, are singular in their nature and effects. The number of ganglia of the spinal cord is usually greater in the larva than the perfect insect, although the great single ganglion of the rhinoceros-beetle (*Oryctes nasicornis*), in its early state, compared with the four ganglia of its subsequent condition, offers an exception to the general rule. But in the larva of the stag-beetle (*Lucanus cervus*) we observe eight ganglia, besides a recurrent nerve, while the perfect insect possesses only four; and among caterpillars in general the same restriction takes place in the number of their ganglionic knots as they attain the perfect state.

Among beings in which the parts representing the brain and other organs of sensation of the higher tribes undergo so many variations even in the same individual, we may well suppose that whatever ideas they are capable of conceiving at one period of their existence, may differ essentially from those with which they are impressed at another. We shall not here involve ourselves in the discussion of the difficult and dissimilar theories of instinct, nor enter into any exposition of the mechanical, the intellectual, or the supernatural character of that surprising manifestation, which, under whatever aspect it may be viewed, whether as differing in kind or only in degree from reason, cannot be otherwise regarded than as a most beautiful illustration of divine benevolence. But we may ask, by what peculiar memory or mode of recollection does the brilliant butterfly, which seeks its sustenance in the nectarous juices of flowers, rifling their sweets with its tubular *proboscis*,—by what means does it remember that its progeny, while in the larva state, must be sustained by a far different diet, and that they exercise their *jaws* on cabbage-leaves, and other vegetation of the coarser kind? M. Virey, who denies all intellect to insects, and views their various actions as resulting mechanically from the peculiar disposition or character of their nervous system, has endeavoured to illustrate the subject by the following parallel. He compares an insect to one of those portable organs, of which the cylinder has different airs noted on its surface, and which performs one or another tune in proportion as the cylinder is made to recede or advance. So likewise the nervous system, or series of ganglia along the double medullary cord, of the creatures now under consideration, being differently constituted in the larva and the perfect insect, ought to produce different actions in the two cases, though respectively appropriate to the nature of each. Art in the one instance, and nature in the other, has impressed certain dispositions, or notes of action, fixed in a determinate series, equally in the musical organ, and the ganglionic system of caterpillars. Hence the one gives utterance to a certain air, while the other acts according to a certain sequence of operations. Pull out a notch of the barrel organ, and you have another tune; await the transformation of the caterpillar to a butterfly, and you have (with a change in the *notching* of its nervous system) another series of instinctive operations. In both, the relations of cause and effect are the same, and each is merely the mechanical playing of an instrument![1] Now, to prove this position, as has been elsewhere remarked, M. Virey ought at least to have shown, that whenever a change takes place in the instincts of insects in their different states of larva and imago, a corresponding change also takes place in the structure of the nervous cord.[2] But this is by no means the case. In three entire orders, namely, Orthoptera, Hemiptera, and Neuroptera, the structure of that cord remains unchanged, and yet we know that thousands of the species which compose these orders acquire instinctive habits in their perfect state, altogether dissimilar to those by which they were characterized in their earlier condition. Even were it otherwise, our query would still require to be answered, by what mechanical impulsion is the completed butterfly, a gay and gorgeous honey-sucker, induced to play a tune (we speak in harmony with M. Virey's views) so completely in accordance, not with its own refined tastes, but with the future welfare of the crawling caterpillars of which it is the parent? Why does it deposit its eggs, not on the odorous blossoms and bright consummate flowers in which it takes so much delight, and amid the varied petals of which it rejoices to expand to the sunshine its own still more brilliant wings, but on the rank leaves of the cabbage and cauliflower, or the dingy foliage of the nettle? These questions, and many others of a similar nature, are perhaps more easily proponed than answered. When we consider, indeed, how frequently inaccurate is our knowledge even of our own individual feelings, and how much more incompetent we are to judge of what passes in the minds of others of our own species, need we wonder that the sentient principles of the lower animals should, in relation to human intelligence, be still shrouded in dim eclipse, if not in total darkness. It is far more probable, however, that the alterations in the nervous cord have no necessary connection with the changes of instinct, but are more closely concerned with those other not less remarkable mutations in the organs of sense and motion, which occur between the larva and imago states of several orders. "In a common caterpillar, the form of the body, the legs, the eyes, and other organs of the senses, all strikingly differ from those of the imago; whereas, with the exception of the acquisition of new wings, a perfect locust differs little from its larva; so that we may reasonably expect a corresponding change, such as we find it in the structure of the nervous cord of the lepidopterous insect, not called for in that of the neuropterous (orthopterous?) species, in which accordingly it does not take place."[3]

Metamorphosis frequently induces no less remarkable changes in the *system of nutrition* of insects, followed of course by corresponding alterations in their instinctive appetites and modes of life. In such as undergo an incomplete metamorphosis, the parts of the mouth, and the form of the alimentary canal, experience no essential alteration; but among those tribes in which the change of external aspect is complete in each successive stage, these import-

[1] *Nouv. Dict. d'Hist. Nat.* xvi. 313.

[2] *Introd. to Ent.* iv. 27.

[3] *Ibid.* vol. iv. p. 28.

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ant parts assume another character, and admirably illustrate the multitude of means employed by nature to vary her innumerable products, even although the general laws by which these are regulated, and from which, under the great and never-slumbering eye of Omnipotence, they more immediately result, are themselves so few in number. The shorter the alimentary canal becomes, the more carnivorous are the tendencies of the individual. This finally exemplifies the great physiological truth previously deduced from the difference between the structure of the alimentary system in herbivorous and carnivorous animals of the higher classes,—between the short canal of the blood-thirsty tiger, and the lengthened convolutions of the gentler ruminating tribes. Here, however, the disparity exists, not as among animals of entirely different attributes, but in the same individual at different periods of its existence. The young of many aquatic beetles of the family of *Helophoridæ* are carnivorous in their larva state, and become herbivorous on assuming their final transformation. A like singularity is manifested by many dipterous flies, which, born and bred amid the putrid moisture of animal remains, no sooner become winged insects, than they seek a purer diet in the nectarous juices of fruits and flowers.[1] Analogous changes take place even in those species which do not entirely alter the nature of their diet. A voracious caterpillar, which, by means of its robust maxillæ, rapidly gnaws and consumes a quantity of the most coriaceous leaves, to the amount sometimes of triple its own weight in a single day, and presents the beau-ideal of an eating machine, has its intestine greatly dilated, and pursed like a colon. The larvæ both of wasps and bees have a stomach so vast, that it occupies almost the entire of their interior, although in the perfect state of each it becomes greatly restricted. Thus in the bee that great laboratory consists of little more than two unequal honey pouches; and among butterflies, of which the trunk or sucker corresponds to the previous jaws, the stomach is much less than in caterpillars. This, we may observe, reverses the rule which applies to the great ruminating animals among the vertebrated tribes, where we find a single stomach in the fœtus state, and which in the adult is multiplied to four. It is the opinion of some naturalists that larvæ in general, having larger intestines, tend more towards a herbivorous diet than perfect insects, in which these organs are shorter, and which are consequently supposed to assume a more carnivorous habit;—"so rare is it," observes M. Bory St Vincent, "to perceive the manners of living creatures not tending to mutual destruction as their powers are developed." An enlightened mind, however, naturally delights in the perception and extrication of general rules; and these, we fear, are not seldom fancied without being either perceived or deduced. In opposition to the presumed law, we have already mentioned the *Helophoridæ*, which reverse the rule; and to these we could add many more. The glow-worm in its larva state is greedy of animal juices, and feeds chiefly on minute testacea, while, in its completed state, it is entirely herbivorous. A large aquatic beetle, the *Hydrous piceus*, is so ferocious and blood-thirsty in the form of larva, as to bear in France the name of *ver-assassin*; but in its after condition, through the medium of metamorphosis, the intestine becomes elongated, and the disposition of the insect is softened and subdued, so that it then prefers a vegetable to an animal diet. In fact the great aim and object of an insect in the perfect condition is rather the continuance of its kind than the sustenance of itself; although, as the one process cannot be well accomplished without the other, it no doubt, even in its most high and palmy state, casts, like its betters, an occasional eye on the "flesh-pots of Egypt."

The changes in the *respiratory system* of insects produced by metamorphosis, are not less extraordinary than those to which we have just alluded. But as we have already mentioned some of the more remarkable of these in our observations on the *organs of respiration*, we shall not further dilate upon that portion of the subject.

Metamorphosis in insects has been described as the maximum state of a general law of nature, by which the whole organization of the animal being is gradually developed and made fit for reproduction. Without the study of this phenomenon, we cannot acquire a knowledge of the most important circumstances in the lives of such animals as are guided entirely by instinct; and just as an acquaintance with the whole life of an insect necessarily induces a truer knowledge of its actual nature, than a mere description of one of its forms,—so, in the same proportion, it has been said, ought metamorphosis to outweigh every other principle of arrangement. When we trace the natural history of a dragon-fly (*Libellula*) from the time that the egg is first dropped into the bosom of the uncertain waters, till, on some bright sunny morning in "the leafy month of June," the gauzy-winged insect in the perfect state is seen to rise from its moist abode, and, hawking for flies, to hover like a bird of prey along the placid shores of some familiar pool, we can scarcely conceive a clear idea of the truth, except by supposing one animal to have been so inclosed within another, that the imago is in a great measure distinct from the repulsive larva, and is only opened to our view by its desiccation or death. Hence, as Mr Macleay observes, a system unconnected with metamorphosis may be regarded as taking no more notice of half the number of true insects than if they did not exist. "It is the defect both of the artificial system in Entomology, and of the sexual system in Botany, that they become useless, except when the objects of the respective sciences are before us in one particular state, which is often the most transitory of their life. Unless this condition be fulfilled, such systems lose their sole and peculiar merit of being dictionaries by which natural objects may be named. There are thousands of organized beings, to the history and knowledge of which the disciple of Linnæus and Fabricius has no clue whatever, although perhaps they are in that state of their existence which most directly affects the interests of man. Plants not in flower, and insects not in their declared state, constitute an ocean of difficulties, in which the most skilled in the Linnæan nomenclature will founder, unless he have other beacons than such momentary considerations as are afforded by the number of stamina, or the form of the antennæ."[2]

We shall conclude our observations on the singular subject of metamorphosis, by another quotation from the last-named author, which, with what has been already stated, will, it is hoped, suffice to instruct the reader regarding what we consider the most extraordinary phenomena observable within the range of the animal kingdom. "It was perfectly in unison with the innate propensity of the human mind towards the marvellous, that the change of a caterpillar into a butterfly, when first noticed, should have been considered by the ancients as a true transformation, irreconcilable with the ordinary course of nature. Even on the mystery being in a great degree cleared up by the discoveries of Libavius, Redi, Malpighi, and Swammerdam, the phenomenon continued to be termed metamorphosis; and perhaps it is even still a little owing to such circumstances that a natural process, neglected in other

[1] *Entomologia Edinensis*, p. 207.

[2] *Hor. Ent.* p. 449.

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branches of zoology, has always excited so much curiosity among entomologists. Metamorphosis, however, has been taken of late in a very general point of view, and rendered synonymous with that species of organic decomposition which, by means of continual shedding of the external envelopes, or even of the various integuments which may compose those envelopes, occasions that extraordinary characteristic of a living body, namely, that it never remains in a constant state, or identically the same, but is continually assimilating new particles of matter, as it throws off the old. And since no metamorphosis can take place except in consequence of these integuments being shed, perhaps it may not be altogether improper to survey the subject in this light. What I mean is, that we ought to regard the metamorphosis or change of form which certain animals undergo at various periods of their life, as an attendant upon, if not a variety of, the *ecdysis*, or moulting, to which all organized beings are subject. There is, however, a great distinction to be made between the *ecdysis* of the *Vertebrata* and *Annulosa*, for in the former we observe little more than that the animal has quitted a sheath in which it was inclosed; whereas in the latter the change is nothing else than if the skeleton were shed; for this name is surely deserved by those hard and solid parts which in so many cases afford support to the muscles. It is clear that such a process must occasion a crisis in the life of an annulose animal, incomparably more decisive in its effects than what can be produced among the *Vertebrata*, by merely being set free from an integument. All the marvellous, however. of *ecdysis*, was with the earlier naturalists comprehended in the change of form; and consequently the shedding of the envelope only excited attention where it regarded a few of the *Annulosa*. Hence it was a great discovery of Linnæus, that every annulose animal ought to be considered as subject to metamorphosis. It may indeed have led to his more artificial notion of every externally articulated being having a nympha state; but even this helped Fabricius to give, although with a faulty nomenclature, a much more convenient division of metamorphosis than he could otherwise have devised.

"Ecdysis, by which term is signified generally every change in the identity of the envelope of a living body, may either be complete or incomplete. If it be incomplete, or, which is the same, if the integuments scale off piece by piece, we have that mode of change which is peculiar to the most perfect of the *Vertebrata*, and to the least perfect of the *Annulosa*.

"Complete ecdysis is the shedding of the whole external envelope at once, of which we have examples among the vertebrated as well as annulose animals. It is of three sorts; first, where the external envelope is shed without producing any essential change of form, except in as much as may relate to the increased size. In those larvæ of insects which become inactive in their pupa state, such a process may always be distinguished from the true metamorphosis; but in apterous Hexapods having active nymphæ, they are necessarily confounded. It is also visible in reptiles and spiders, where such appendages of the trunk as have been lost may be reproduced by continued moulting. When the various envelopes are all cast as it were in one mould, it is to be expected that the proper form of the animal should re-appear as these continue to be thrown off. The return therefore of a spider or crab, after having lost a limb, to its original form, may be in some measure understood as depending on the manner in which such animals shed their envelope; but that the limbs thus shot forth should be furnished with muscles and nerves, is, I conceive, what cannot be accounted for, except by referring to that polype nature of the cellular substance, which is perhaps, in the opinion of some persons, the foundation of all ecdysis. If perfect hexapod insects cannot reproduce their members, this inability may probably proceed from a cause which appears to have produced the same effect among *Mammalia* and birds, to wit, that these animals in their perfect and final form are all subject, if to any, at least to a very imperfect ecdysis.

"The second sort of complete ecdysis is that where the under envelope has been cast in a somewhat different mould from the upper, so that in the course of the moulting certain new parts become gradually developed without the general form being in any material degree altered. This is observable in every annulose class, as well as in Humboldt's Axotl among the *Vertebrata*, and is the first species of change which merits the name of metamorphosis. It includes the *Metamorphosis inchoata* and *Metamorphosis dimidiata* of Latreille, and is the same with the *Metamorphose partielle* of Lamarck.

"The third sort of complete ecdysis is that wherein, by some two or three moultings, generally the last which the animal has to undergo, the form is entirely changed, as well as the number of appendages more or less increased. This is clearly a true metamorphosis, and includes the other two sorts of complete ecdysis; for we have here combined a total casting of the integuments, a development of additional appendages, such as feet or wings, and finally an entire change of form. Such a combination may be witnessed, among the *Vertebrata*, in frogs, and, among the *Annulosa*, in certain hexapod insects. Hence, in confining ourselves to plain and open ecdysis, there will be no great error in stating that the most imperfect takes place in the highest *Vertebrata* and the lowest *Annulosa;* while the most complete ecdysis is that which is seen to prevail in the highest *Annulosa* and some of the lowest *Vertebrata*.

"In strict accuracy, however, it appears that we ought to acknowledge the existence of complete ecdysis throughout the circle of *Vertebrata*. Nay, some physiologists have attributed insect metamorphosis itself to a shedding of an envelope analogous to that which contains the fœtus of the more perfect *Vertebrata*. As every embryo, whether animal or vegetable, is enclosed in a tunic more or less solid, which is its chorion, so, proceeding with the analogy, they conceive that there must be some condition for every animal, similar to the state of the fœtus of the more perfect animals when surrounded by the amnios; and this state in batrachian reptiles and hexapod insects they hold to be the larva. The only danger of this reasoning is, that while we find the birth of an animal to be attended with complete ecdysis, we may be apt to imagine that every complete ecdysis betokens a true birth. It would, however, be truly absurd to consider the casting of their shell by *Crustacea*, or the periodical moulting of the serpent, in this light; yet no one can doubt the fact of both these being cases of complete ecdysis, only differing from that of *Lepidoptera*, because in the former animals the external envelope is always of the same form as that of which it is to take the place. The truth perhaps is, that we ought only to allow two states to every animal, a perfect and an imperfect state. Then, by the reflection that no animal out of the circle of *Acrita* can ever arrive at its perfect state except by means of metamorphosis, and that when perfect it can never again be subject to this change of form, though it may still moult or shed its external envelope, we may be able, if not to comprehend the cause, at least to know the effect, of some of the most puzzling phenomena in nature. The true criterion of animal as well as vegetable perfection is the ability to continue the species; hence some of the *Vertebrata*, as well as *Annulosa*, gaining this faculty before they have arrived at their proper type of form, metamorphosis ceases, and they preserve the shape of larvæ.

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"But if a complete ecdysis may sometimes create a total change in the external appearance of the animal, the fact, however astonishing, is nothing in comparison of the internal metamorphosis which accompanies it, and of which as yet no philosopher has been able to give any satisfactory explanation. The generalization indeed by which we have reduced the moulting of a bird's feathers and the metamorphosis of a butterfly to one principle, may appear to be strained beyond its proper limits; yet if we contemplate the regular gradation from one to the other, how truly, for instance, the inactive pupa of a beetle corresponds with the agile nympha of a *Gryllus*, how this ecdysis in an apterous *Gryllus* corresponds with the sloughing of a spider, and this again with the annual renovation of the serpent, we must be sensible that, however dissimilar the extremes may be, all these changes are modifications of one principle. But what particularly deserves remark is, that these extremes should often be visible in neighbouring groups; nay, in the same order; that, in short, metamorphosis should differ so much in degree even where the animals are near in affinity. An orthopterous insect may preserve the same form and habits from the instant it quits the egg up to the period of its death, the only qualities obtained by ecdysis being an augmentation of size and an aptitude to continue the species. But if we turn to the order of *Coleoptera*, which is contiguous in affinity, it is truly wonderful that, by metamorphosis, not only the form, but the nervous and digestive systems, may be altered, and the organs connected with these primary functions may all be of a construction different from that which they originally possessed."[1]

The reader has now been made acquainted in a general way (and as precisely as the limits of our present article may admit) with the most characteristic features in the structure of the insect tribes, from which he may form some opinion of their real nature. Their relative position in the magnificent range of created things is a subject deserving of a deeper and more extended examination than we can here bestow upon it; but as we are unwilling to leave such an interesting matter of philosophical consideration entirely unregarded, we shall here enter into it in the only way compatible with our prescribed limits.

CHAPTER V.

OF THE RELATIVE POSITION OF THE CLASS OF INSECTS IN THE ANIMAL KINGDOM.

A great diversity of opinion has existed from the earliest ages regarding the natural affinities of the different kinds and classes of animated beings to each other, and a consequent contrariety has prevailed in our systems of classification, which are of course indications of the relation of groups, unless where, for mere convenience, a professedly artificial basis of arrangement, deduced from one or two obvious though unimportant characters, may have been adopted. The majority of naturalists, both ancient and modern, have proceeded upon the idea that all natural objects were *concatenated*, or formed a continuous *chain* or linear series, and that whatever hiatus might seem to exist arose either from some great convulsion which had swallowed or swept away the desired links, or from these links being still to be discovered in one or other of those regions of the earth's surface which still remain to be explored. Hence the dictum of Linnæus—natura saltus non facit. "When the ALMIGHTY CREATOR," says Mr Kirby, "willed to bring into existence this mundane system, he formed it according to a preconcerted plan, with all its parts beautifully linked together and mutually corresponding. All things were ordered in *measure*, and *number*, and *weight*.[2] There was nothing deficient, nothing superfluous; but the whole, in the strictest sense, 'was very good,'[3] and calculated in the highest degree to answer the purpose of its GREAT AUTHOR."[4] Observation and analogy alike combine to prove that there is a regular approximation to each other in the works of God, and that they are related to each other in a variety of ways both naturally and analogically; but it need not be supposed that, in the magnificent plan of the creation, there is no disparity in the relative position of the most nearly related kinds, and no greater interval in one place than another. There is in truth a great variation in the combinations of living beings, though no violent break or sudden interval; in other words, "some continuous species or groups have more characters in common than others." But in considering the various groups of living creatures, we must ever bear in mind our own ignorance of their actual amount, and the thousands of unknown forms which in all the pride of life may be daily unfolding their exquisite forms and gorgeous colours amid those far deserts where man has never trod, and which for that very reason he regards as *solitudes*, though assuredly teeming with all the inexplicable wonders of creation. Let not therefore a *hiatus* be confounded with a *saltus*, the former being merely one of the many blanks in the superficial map of knowledge drawn by man, the latter an absent link in that resplendent chain, to us too often "dark with excessive light," which in one way or other connects together in divinest harmony the beautiful works of the Creator. That the series of beings, however, was not only continuous, but *undeviating*, and ascended in a direct line from the lowest to the highest, was maintained, among many others, by the excellent and ingenious Bonnet, and has generally prevailed till very recent times.

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Now the principle which mainly characterizes the views so mildly advocated by Mr Macleay, and entertained, we believe, about the same period, although without communication, by Agardh, Fries, and other continental naturalists, is this,—that although the natural arrangement of objects is indeed in a continuous series, that series in its progression forms various convolutions, each of which may be represented by a *circle* or series returning into itself. He maintains that absolute divisions do not exist in nature, and that a single plan pervades the universe, a plan founded on the principle of series of affinities returning into themselves, and forming circles; hence there is no such thing among natural objects as a simple progression of species.[5]

If it were true that the descending scale, as so long supposed, in the perfection of organization, was regular from man to the infusorial tribes, then the lowest of one form of life would naturally lead to the highest of the next ensuing, and the most simply organized of the vertebrated classes would connect most nearly with the most complex of the invertebrated kinds. But this, as we shall afterwards see, is not the case.

Although naturalists, if we may judge from their sys-

[1] *Hor. Ent.* p. 441. [2] *Wisdom*, xi. 20. [3] *Genes.* i. 31. [4] *Introduc. to Ent.* iv. 356.

[5] The latter sentiment appears to have been also entertained by Latreille in his later years. Writing of certain coleopterous insects, he observes, "Les Dryptes ont aussi des rapports avec les Cychrus, et paraissent lier les Cicindelètes avec la section des Carabiques grandipalpes. Plusieurs sections de cette famille semblent se rattacher, comme autant de rameaux, aux Cicindèles. La plupart des autres familles d'insectes sont dans le même cas, ou forment des troncs ramifiés. *En un mot, des séries continues n'existent pas dans la nature.* (Note to *Règne Animal*, t. iv. p. 373.)

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tems of classification, are accustomed to consider the insect tribes as inferior in the great range of organization to the molluscous animals which inhabit shells, there can be no doubt that they are superior in many of their vital functions. Their powers of locomotion, whether as winged, aquatic, or terrestrial creatures, are finely developed, and their perceptive faculties are much more acute. The symmetrical perfection of their forms, and the articulation of the limbs, in the insect class, seem also in some measure to connect them with the vertebrated tribes. Indeed, even of the latter, many seem far inferior to insects, not only, as Mr Macleay has observed, in the possession of those faculties by which we are accustomed to estimate the rank of the *Vertebrata* among themselves, but also in the complication of their general structure. These and other considerations afford powerful arguments in favour of the *circular* system; for it appears necessary, first, that certain affinities of the *Mollusca* to the *Vertebrata*, and which are obvious in the *Cephalopoda* or cuttle-fish, should not be disturbed by any intervening division; and, secondly, that the annulose animals themselves, such as insects, Crustacea, and Arachnides, should not be far separated from *Gastrobranchus* and other genera of cyclostomous fishes; above all, that they should not be made subordinate in rank to such simply organized creatures as compose the greatest part of the Mollusca. "Now these conditions will all be fulfilled if the chain of nature be viewed as returning into itself; whereas they will be completely violated if we account it to be a regular line or ladder, commencing with the *Infusoria*, and terminating in man; or indeed if we adopt any opinion that has hitherto been advanced on the subject by naturalists."[1] It seems to have been chiefly owing to the perfection of the circulating system in molluscous animals that they have obtained their present rank; for, in regard to the nervous system, which would have been a truer test, although such tribes as possess a distinct head, and are furnished with tentacula and other organs of sense, have undoubtedly a true brain, yet oysters and many more *acephalous* kinds can lay no other claim to the possession of that organ than what is derived from the analogy which its position in these Testacea is supposed to bear to that of the brain in the gasteropoda. It is a strong fact, however, that so skilful an interpreter of nature as Baron Cuvier should have been determined by that analogy, and should have acceded to the acephalous Mollusca the possession of a brain, and a general construction, which, upon the whole, he regards as making a nearer approach to that of the *Vertebrata* than is effected by any annulose animal. Yet in spite of this it would be difficult to contend that an *Ascidia* is in any respect superior to a bee, as no one who has ever seen the two, and observed their respective functions, would venture to bring the sluggish mollusc into competition, either as respects intelligence or complication of mechanism, with the delightful emblem of industry.

When we call in the aid of anatomy to determine the relative importance which different material beings bear in the scale of the creation, we must consider the beauty of the general mechanism and (speaking humanly) the difficulty of the workmanship, and not any "fancied and often forced resemblance to the human structure."[2] It is in truth a great error to regard the works of the creation as referable to the human structure, as a standard of perfection; for although the frame of man, when taken as a whole, ought doubtless to be regarded with wonder and admiration as a most complicated yet complete machine, there is at the same time as little doubt that we scarcely possess a single sense or bodily power in which we are not excelled by some irrational beings. Different animals have in fact been constructed on different plans, and man may without impropriety be regarded as upon the whole the most admirably constructed creature of all those which have been organized upon the same general plan with himself, but with the others he cannot be compared.

In the article Animal Kingdom of this work we have already shown the importance of the nervous system in the formation of the greater divisions of living creatures, and we there exhibited the relative positions occupied by the different classes of animals in the works of the most distinguished systematic writers. Lamarck divides the animal kingdom into two great branches,—the one containing all those living beings of which the skeleton is *internal*, and constructed upon a bony and articulated column, hence called *Vertebrata*,—the other consisting of those innumerous kinds of which the skeleton is either wanting, or its supposed analogue is for the most part *external*, and includes the muscles; these are the *Invertebrata*. This grand distinction is strongly marked throughout the great mass of each division, but it begins to disappear wherever the provinces approach each other. Thus among the turtles or chelonian reptiles, the vertebral column is converted to a row of square osseous plates, which run along the back, and unite with eight pair of expanded ribs, which are anchylosed together by real sutures, and combine to form in fact the *external* carapace or shell. In like manner the vertebral column almost disappears among the cyclostomous fishes, while, on the other hand, the Cephalopoda, or cuttle-fish, though belonging to the invertebrate division, exhibit the commencement of an internal skeleton. M. Virey, as we have shown in the article above referred to, divided the animal kingdom into *three* great branches, according to the different character of their nervous system. Baron Cuvier, proceeding upon the consideration of the same important basis, includes all animals within *four* primary divisions; while Mr Macleay, according to his peculiar views, perceiving *five* great sub-kingdoms in the magnificent *circle* of living things, has assumed that number of divisions. We shall here present a sketch of his system, so far as relates to the primary forms, the majority of which agree with those of his predecessors, although their relative position, and circular sequence, if we may so call it, differ.[3]

1*st*, There is a great tribe of beings which possess one principal centre to their nervous system, the great trunk of which, with the said centre, is contained in a bony articulated case, which forms the axis of the whole body, and constitutes the vertebræ and skull of these creatures, which are therefore named Vertebrata.

2*d*, In another form of animals the skeleton is as it were external, so as to envelope the whole body, and is divided by transverse folds into a certain number of rings, to the internal surface of which the muscles are always attached. Their nervous system consists of two long strings of medullary matter, passing through the whole of the body, and united to each other, at small distances, into several knots or ganglia. These ganglia may be said to perform for the parts which surround them the function of so many brains, and for a certain period are even sufficient for ner-

[1] *Horæ Entomologicæ*, vol. i. p. 206.

[2] *Ibid.*, p. 405.

[3] As the book entitled *Horæ Entomologicæ* has been long out of print (the author has never brought out a second edition, and the first was almost totally consumed by fire), our occasional exposition of its peculiar and prevailing doctrines cannot prove otherwise than interesting to the considerate reader.

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vous sensibility after the animal has been cut in pieces. All the beings so constructed are named Annulosa.

3d, In a third prevailing form there is no articulated skeleton either external or internal, the muscles being attached solely to the skin, which is itself in general soft, though often protected by a calcareous or stony crust, termed the shell. These animals, remarkable, like plants, for the variety of modes in which the sexes are combined, have their nervous system composed of several masses or ganglions united together by nervous threads. The constituents of this group are almost all aquatic, and are named Mollusca.

4th, A fourth form of animal life exhibits to our view the organs of locomotion and sensation arranged in a circular disposition round a centre, so as to give a sort of radiated aspect to the whole body. They are composed of a more or less gelatinous substance, of which the fibres are indistinct. The nervous system of these imperfect beings is but little known. M. Tiedemann, in a work crowned by the French Institute (*Mémoire sur l'Anatomie des Astéries*), conceives that the whitish threads which proceed in a radiant direction from around the mouth, and which extend themselves through the entire length of the arms of these animals, form a kind of nervous system, which, from the pulpy nature of the medullary matter, seems to correspond with the gelatinous composition of the animals themselves. They are all aquatic, and are named Radiata.

5th, Thus far these groups agree in number and constitution with the four primary divisions established by Baron Cuvier,—the *Annulose* division corresponding with the *Animalia Articulata* of the French naturalist, except that it excludes the *Annelides*, or red-blooded worms, and includes certain radiated species (commonly so called), such as the intestinal group denominated *Intestinaux Cavitaires* by the French, or *Entozoa Nematoidea* of Rudolphi. But, according to Mr Macleay's views, there still remains a *fifth* form of animal life to be considered,—a group of beings which cannot in the present state of knowledge be better described than as masses of a transparent, homogeneous, mobile, and sensible pulp. There may, however, be observed in this translucent mass innumerable minute granulations, which may be regarded as the nervous molecules dispersed over, or as it were confounded with, the substance of these animals, so as to endow the whole with sensibility, or something which the author calls such, probably for want of a better name. This final division is named Acrita.[1] Its constituents form a portion of the *Animalia Radiata*, or fourth primary division of the Cuvierian system, and include the infusory animals, many of the intestinal worms, and the *polypi*. Their distinctive character is principally negative in reference to animals, and positive in regard to plants. The simple texture of their cellular tissue is common to them and to the *Algæ*. Their gemmiparous generation is allied only to the very simplest mode of the reproductive system among other animal tribes, but is by no means unfrequent among plants. The method by which they are more or less sustained by the absorption of their external pores, and the attractive influence exercised on them by light, are likewise features only elsewhere to be observed among the vegetable tribes. When a polype is cut in pieces, each of these continues to live, and in time assumes the original form, so that every point of such an animal body may be regarded as possessing an independent life, like that of the lower plants. Lamarck accounts for this peculiarity by regarding their alimentary canal as constituting a second absorbing surface, in no way different from the absorbent external surface of the *Agastria*, or infusorial tribes, so that any portion separated from their bodies may live for a time, like the Infusoria, until they have obtained the second or internal absorbent surface.

"On considering," says Mr Macleay, "the gelatinous composition of these animals, the dispersion of the nervous molecules through their substance, and the absolute certainty that they are devoid of every sense, except perhaps those of taste and touch, we are led to connect them with the *Mollusca*, whose substance is always mucous, and often even gelatinous,—whose nervous system, though collected into several *ganglions*, or *centres of sensibility*, has nevertheless these ganglions dispersed, with little if any arrangement, throughout the whole mass of their body,—and whose senses, so far at least as we are certain of their existence, seem to be confined to those of taste and touch, with the exception of a few animals of the division which possess the organs of sight, and still fewer which possess those of hearing.

"Nevertheless, on comparing the *Acrita* with the *Mollusca*, we find that the organization of these last has become much more complicated, and that a distinct system of circulation, and peculiar organs for respiration, digestion, and secretion, are even visible in these animals, which connect them in a remarkable manner with a still more perfectly organized family—the *Vertebrata*.

"These, however, by their red blood, their muscular heart, their jaws acting vertically, their distinct organs for sight, hearing, smell, and taste, their sexes constantly distinct, their vertebral column, and extreme concentration of the nervous system, are sufficiently insulated from the *Mollusca*, as well as from all other material beings. The group is therefore perfectly distinct and natural; yet if we attempt to define it by any of the above-mentioned various properties, little examination is requisite to convince us that the characteristic thus chosen either disappears in the least perfect of the *Vertebrata*, or passes imperceptibly into the neighbouring groups.

"Thus in the fishes which compose the genera *Ammocætus*, Dum. and *Gastrobranchus*, Bl. all those parts which ought to have constituted their skeleton as vertebrated animals become so soft and membranaceous that they may be considered as having no bones. The organs of respiration and of manducation, the absolute want of the sense of sight, the general habits and external form of these singular fishes, all prove to us that they are connected with the *Annelides*, and that by them nature passes to the structure of the *Annulosa*. On the other hand, on examining some of the *Echinoderma* of Cuvier, such as those composing the genus *Comatula*, we may trace the articulated texture of the *Annulosa* into the division of *Radiata*, many of whose external forms are also exactly imitated by the sessile *Cirrhipedes*. Of the *Radiata*, again, the stellate form and the gelatinous semitransparent substance are observable among the *Acrita*. So that the chain whose links we have endeavoured to unfold returns into itself, and we find that all animals form a circle composed of the following great divisions, viz.

Acrita,
Mollusca,
Vertebrata,
Annulosa,
Radiata.

[1] "Animalia gelatinosa polymorpha, interaneis nullis medullâque indistinctâ. Os interdum indistinctum, sed nutritio absorptione externâ vel internâ semper sistit. Anus nullus. Reproductio fissipara vel gemmipara, gemmis modo externis modo internis, interdum acervatis. Pleraque ex individuis pluribus semper cohærentibus animalia composita sistunt." (*Hor. Ent.* p. 224.)

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"This arrangement of animals is, it is true, quite distinct from that generally adopted; but it will be seen that it is not only conformable to nature, but that it removes many of the discrepancies which shock the naturalist in the common systems. For instance, there is an acephalous animal of the division *Mollusca* (*Ascidia mammillaris*, Linn.) which exists without any visible organs of sense except that of taste, whose substance is little better than a homogeneous gelatinous pulp, whose inert nature seems to deprive it of any power like that of voluntary motion; a being which is consequently reduced to fix itself to solid bodies, or to be the sport of winds and waves, whose principal sign of life consists in the absorption and spouting forth of water, and whose animal properties, in short, are all comprised in its irritability, its circulation, and respiration. Yet because these two last qualities appear in this animal, whose existence is little better than vegetative, to bear some resemblance to the circulation and respiration in some of the *Vertebrata*, we find it placed in the common systems before the bee, which astonishes us by its industry and social qualities; before the ant, which excites our admiration by its frugality and courage; and before the other numberless insects, which by their manners and stratagems have often made the naturalist hesitate as to the point where he would draw the line, and separate instinct from reason."[1]

Mr Kirby seems equally inclined to accord a step of precedence to the insect and other annulose or articulated tribes over the Mollusca, or at least to maintain that the latter should not be interposed between the former and the vertebrated tribes. "If you inquire," says he, "into the rank of each of these sub-kingdoms, of course you will assign the principal station to the *Vertebrates*, which are the most perfectly organized, to which man belongs, and over which he immediately presides. If we form the scale according to the nervous system of each province, that in which the organ of sensation and intellect is most concentrated will stand first; and in proportion as this organ is multiplied and dispersed, will be the station of the rest, which will place them in the order in which I have mentioned them; and the *Annulosa*, to which insects belong, will precede the *Mollusca*, which Cuvier and Lamarck had placed before them on account of their system of circulation. But when we reflect that a *heart* and *circulation* occur in some of the conglomerate *Polypi*,[2] animals that approach the *vegetable* kingdom; that some of the acephalous *Mollusca* have no visible organs of sense except that of taste, whose substance is little better than a homogeneous gelatinous pulp, and who seem from their inert nature to have very slight powers of voluntary motion;[3] we shall be convinced that a heart and circulation alone, unaccompanied by a more concentrated nervous system and more perfect structure, cannot place an animal above those which in every other respect so obviously excel them. With regard to *insects* particularly, we may further ask—who that considers how man employs his powers and organs even in his most degraded state, or that contemplates the wonderful works that he is enabled to accomplish when his faculties receive their due cultivation and direction, can avoid regarding him as superior to the rest of the animal creation? And what unsophisticated mind, not entangled in the trammels of system, when it surveys the industry, the various proceedings, and almost miraculous works that have been laid before you,—the waxen palaces of the bee,—the paper cottages of the wasp and hornet,—the crowded metropolis of the white ants,—the arts, the manufactures, and stratagems of other insects,—the associations and labours for the common good of those that are gregarious;—will not at once conclude that they must be a superior race to the slug, the snail, and others, which live only to eat and propagate their kind? Or who, that considers the wonderful structure of the animals whose cause I advocate,—the analogy that exists between their organs of manducation, of motion, and of sensation, and between various other parts of it, with those of the higher animals,—the acuteness of their senses, their wonderful strength of muscle, and powers of locomotion,—but will think them superior to the headless and almost inanimate oyster or muscle, or the conglomerate *Alcyonia*, though they have a heart and circulation. Who, again, that observes, that in proportion as pedate animals approach to the human type, their motions are accomplished by fewer organs,—that man walks, *ore sublimi*, upon *two legs;* the majority of quadrupeds upon *four;* insects upon *six;* the *Arachnida* apparently upon *eight;* most *Crustacea* upon *ten;* and the *Myriapods* and others upon *many*,—but will thence conclude that insects must precede the *Arachnida* and *Crustacea?* Who, once more, that reflects, that if any of the superior animals are deprived of a limb, it can never be reproduced, and that in insects the same circumstance occurs; while spiders and *Crustacea*, if they lose a leg, have the power of reproducing it; and the *Mollusca*, if they are decapitated, can gain a new head,—will consent to their being placed after any of these animals?[4] Lastly, who that recollects that the *Mollusca* are hermaphrodites, like most plants, bearing both male and female organs in the same body, but will allow that insects, in which the sexes are separate, as in the Vertebrates, must be more perfect, and of a higher grade?"[5]

Whoever regards the different classes of the animal kingdom with an observant and discriminating eye, will not fail to perceive that the knowledge of any organ in one particular division of nature is insufficient to enable us to judge of its importance; for such are the changes in the organization of animals, that a system of organs which performs the most important functions in the first division, may either not exist in the next, or be found in a secondary condition, and subordinate to some other system which has acquired the preponderance. In truth, the anatomy of the higher classes having been first profoundly, or at least laboriously studied, before the requisite attention had been bestowed on the structure of Invertebrates, all those organs and functional actions which were invariably more or less sustained and apparent in these first divisions, have been regarded as fundamental, and for this reason alone an equal importance in our systems of classification has been attributed to them throughout the whole animal kingdom. From this course of proceeding, as noticed by M. Straus, approximations have resulted which break the natural relationship of many divisions. For example, in the first great division of animals, respiration and circulation being in fact two functions to which all the rest are more or less subordinate, it has been imagined that we ought to regard them as essential in the whole series of animals, and employ them as the sole basis of classification. Among the Vertebrata these functions indeed afford the firmest foundation for a natural distribution; but amongst other classes, on the contrary, in which they are only secondary, their adoption has led to the

[1] *Hor. Ent.* p. 202. [2] Savigny, *Mem. sur les Anim. sans Vertèbr.* ii. 1, 3. [3] *Hor. Ent.* 204.
[4] In this respect insects excel many reptiles, which can reproduce some of their parts.
[5] See Macleay, *Hor. Entomolog.* 203, 206, 208.

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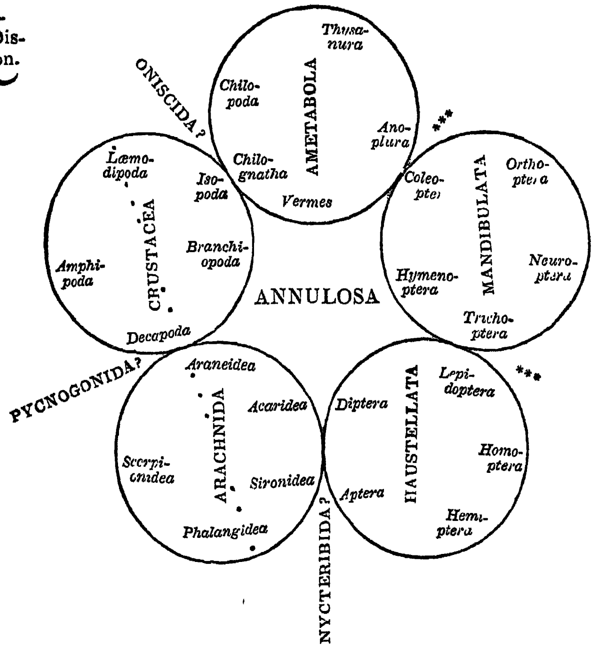
gravest errors and most palpable contradictions; for it not unfrequently happens that one family of Invertebrata which respires by branchiæ, cannot be separated (keeping numerous natural affinities in view) from another family in which the respiration is pulmonary or tracheal.[1] One great principle of creation being to combine variety in the means with uniformity in the effect, we find that among molluscous animals the circulation of the blood varies in its manner *ad infinitum*, and has thus led to the most artificial arrangements. Yet few animals in existence have the organs of circulation more complicated than some of the Cephalopoda. Among the annulose animals, also, in which the nature of the nervous system is so uniformly accordant, circulation varies from an extremely perfect to an evanescent state. A mode of nutrition and respiration takes place so entirely different from that exhibited by the vertebrated and molluscous tribes, that they never can be regarded as modifications of the same system. As, then, the general plan of construction of these animals is so different, Mr Macleay regards it as necessary to suppose that the new and dissimilar system of respiration is that which more peculiarly characterizes the annulose group, or, in the author's words, "is that to which the structure of the animals forming the group tends." And what makes this supposition the more probable is, that the Annelides, or red-blooded worms, which, of all the articulated tribes, are placed by Cuvier the nearest to the vertebrated classes, are nevertheless imperfectly organized, and of as dull perceptions as any of the annulose division. This could hardly be the case were the Annulosa to be considered with propriety as modifications of the vertebrated structure, while, on the other hand, those annulose classes which respire by tracheæ, and coincide in nothing with a vertebrated animal, are, nevertheless, the most active and industrious of their group, although their activity and industry are of a nature entirely different from what is observable among the vertebrated tribes. Now it is difficult, if not impossible, to account for all this, unless we regard every vertebrated creature to have been constructed by the great Creator with reference to one type, and every annulose with reference to another; and as the former is more imperfect in proportion as it approaches the annulose structure, so the latter also becomes more imperfect in proportion as it obtains a distinct system of circulation and other characteristics of the vertebrated tribes. It thus follows that the animals which connect them ought to be extremely imperfect in their organization; and this conclusion is well supported by the sluggish Annelides, in which organs of sense are barely perceptible, and organs of motion by no means so perfect as among the larvæ of insects.[2] M. Straus also maintains the opinion that it is the less perfect species of any one great group which approach most closely to the group which precedes or follows them, and that it hence results, that in any division, the species which offer the most elevated organization may be more perfect than such as are placed at the lower confines of a higher division. He admits that a more natural passage exists from the Vertebrata to the Annulosa, than from the former to the Mollusca; but this connection he considers is by the lowest in the scale of organization of each of these groups. As soon as the Vertebrata reach the most simple form compatible with their mode of organic life, the great Author of nature commences from that point a new group, that named *Annulosa*, by successively introducing a new series of organs altogether different from those he has abandoned, and by considerably modifying those he has retained. The genus *Ammocætes* (and perhaps also that of *Myxine*) form this point among the Vertebrata, while *Gordius* and *Hirudo* compose the corresponding link among the annulose tribes. On either side these animals find their place at the lowest point of the descending scale, formed by each of these two series; and, compared with each other, the two genera of fishes just named, and the abranchial *Annelides*, present some remarkable resemblances in the few organs which they possess.

The opinion that insects and other annulose animals are more nearly connected with the Vertebrata than are the Mollusca, is regarded as true by M. Straus Durckheim, both in regard to the modes of organization according to which these three divisions are formed, and in relation to the degree in which their faculties are developed. The Vertebrata, he observes, are characterized by an articulated body, of which the two lateral halves are symmetrical, and are sustained by an internal skeleton, the central portion of which is composed of a series of parts, to which the other osseous parts are attached. In the Annulosa the symmetry of the two sides of the body is still greater than in the Vertebrata; the body is likewise articulated, and formed by a series of central parts, to which the others are attached, although they have no internal skeleton. The nervous system in both consists principally of a spinal marrow, from which arise most of the nerves of the body; but there is this difference in the Vertebrata,—the spinal marrow is dorsal, whereas it is ventral among the annulose tribes. The muscular system is also as fully developed in the one as in the other, and offers nearly the same distinct forms. The Mollusca, on the contrary, exhibit characters totally at variance with those now mentioned; for, on the one hand, their body no longer exhibits a perfect parity of parts, nor is it in any degree articulated; on the other, the nervous system is not longitudinal, nor its situation constant, while its mass is greatly decreased. The muscular system is also in general much less perfect, and, considered in detail, the muscles are less distinct, and only form, throughout the greater part of the body, a mass of fibres so interlaced as to be incapable of separation, thus conducting us to *Entozoa*, of which the body is only a continuous *parenchyma* without distinct muscles. According to the author last named, the character which eminently distinguishes the Mollusca from the two other divisions is, that in these the organs of *animal*, in the Mollusca those of *vegetable* life, are the most predominant; from whence it follows that the latter are totally devoid of industry, and of that higher mode of perception approaching to *intelligence*, which insects possess in a degree surpassing all other invertebrated tribes.

Having entered into the preceding investigation with the view of illustrating the true position of the annulose division in relation to the other sub-kingdoms of animal life, we shall now, in more direct reference to the proper subjects of our present dissertation, that is, the hexapod or six-footed insects, exhibit, by means of the following diagram, the views entertained by Mr Macleay regarding the natural affinities observable among the annulose tribes themselves. The reader will perceive that the circles of *Mandibulata* and *Haustellata*, with those portions of *Ametabola* named *Thysanura* and *Anaplura*, constitute the true INSECTA, such as we have defined them at the commencement of this article.

[1] See *Considerations générales sur l'Anatomie comparée des Animaux Articulés*, &c. par M. Straus Durckheim.
[2] *Hor. Ent.* p. 295.

Geographical Distribution.



Our next subject of consideration is one which has not previously formed a part of any of our encyclopædias of knowledge.

CHAPTER VI.

THE GEOGRAPHICAL DISTRIBUTION OF INSECTS.

This topic has indeed been much less attended to as a matter of philosophical investigation than it deserves. When we take an extended view of the general distribution of animals and plants, we find that they are usually disposed over the earth's surface in bands or parallel zones, corresponding in a great measure with the peculiarities of temperature and climate which are appropriate to the nature of each. When the temperature of a particular latitude becomes colder, as on mountains or highly elevated plains,—or warmer, as on plains by the sea shore, or in low lying sheltered valleys,—we find, in the former case, that the species approximate in their nature and characters to those of a more northern, in the latter to those of a more southern parallel. Of course the zones of vegetable and of animal life do not correspond at all strictly with the *latitudinal* lines of our geographical system. Humboldt has indeed shown, that within 15° or 20° from the equator, the mean annual temperature is nearly the same in all longitudes of equal elevation, or is at least but slightly varied by local circumstances. In other words, the isothermal lines are more regularly parallel with those of the equator. But in temperate and northern countries the same uniformity of temperature in each portion of the same parallel is not observable; all western coasts, and districts of continents and of considerable islands, being of a higher temperature than those of the same latitudes along the eastern shores. The mean temperature of the North Cape, under the seventy-first degree of north latitude, does not exceed, indeed corresponds with, that of Labrador, which is 14° further south; and that of the west of Ireland, in the fifty-fourth degree, agrees with the forty-third parallel in the United States.

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In relation to zoological geography, indeed, there are several other minor circumstances which tend to change or counterbalance the more usual results, and consequently to derange such calculations as might very reasonably be formed upon a knowledge of latitudinal and longitudinal position, and of the height of a country above the level of the sea. The nature of the soil and surface, the different degrees of dryness and humidity, and the consequent character of the climate and vegetation, the comparative extent of land and water, the extent and continuity of forests, marshes, and sandy deserts, the direction of mountain ranges, and the form and position of lakes;—these and several other circumstances must be taken into consideration, and will be found materially to affect the distribution of animal life over the surface of the earth.

It does not appear that the climates of insects, or those peculiarities of temperature and other physical attributes under which certain groups or species appear to predominate, have been as yet studied in connection with our imperfect knowledge of isothermal lines. Humboldt, indeed, has remarked, that the geographical stations of the gnats and some other insects of South America did not appear to depend solely on the *heat* of the climate, the excess of humidity, or the thickness of the forests, but on local and unappreciable circumstances.[1] It is evident, however, that the characteristic stations of insects are mainly dependent on the degree of temperature, so influential on the development and distribution of all the other varied forms of animal life. An increase of caloric seldom fails to produce a corresponding increase and alteration in the number and character of entomological forms; and when we travel from the hyperborean regions towards the sunny south, we find that the tiny multitudes accumulate in all the warmer portions of the temperate zone, till they swarm between the tropics. Otho Fabricius resided six years in Greenland, and during that period he collected only sixty-three species of the insect class, properly so called. In the still higher latitude of Winter Harbour, where Sir Edward Parry sojourned, only six species were collected from the beginning of September till the August following. Mr Kirby has stated that in Greenland every order of insect has its representatives, except Orthoptera and Hemiptera; but in Melville Island, besides these deficiencies, neither coleopterous nor neuropterous species exist, or at least were observable; and even the mosquito, that shrill tyrant of the Lapland plains, appeared to have ceased from troubling along those hyperborean shores. The most northern locality of any insect yet ascertained is that of the *Aphis borealis*, taken in latitude 82° 26′ 44″, about one hundred miles from the nearest known land.[2] It is probable, however, that the distribution of many northern species is still unknown. It was formerly supposed that in Iceland there were none, and that even in Norway there were very few, their absence from those countries being attributed to excess of cold. This opinion, however was contradicted by Horrebow, so far as Iceland was concerned; and Olafsen and Povalsen, during their sojourn there, collected 200 different species in one small valley It must indeed be borne in mind, that insects can escape the extreme of cold, not only, as Mr Macleay observes, by passing certain periods in the *pupa* or torpid state, but also by being while in that condition usually buried in the earth, where they are greatly protected from the rigours of the winter season. "What they chiefly re-

[1] *Personal Narrative*, vol. v. p. 88.

[2] This species was found in the boat during the last day of Sir E. Parry's attempt to reach the north pole over the ice. There was no vestige of vegetation around the adventurous party; and we think it more probable that the forlorn insect had been carried, *nolens volens*, from a somewhat more southern quarter.

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quire is the presence of heat during some period of their existence; and the greater, within certain limits, is the heat, the more active will be their vital principle. On the American continent the extremes of heat and cold in the course of the year are, as is well known, incomparably greater than in places of the same latitude in Europe. We may therefore readily conceive how particular families of insects will inhabit a wider range of latitude in the former country than in the latter. We see also how insects may swarm in the very coldest climates, such as Lapland and Spitzbergen, where the short summer can boast of extraordinary rises in the thermometer; because the energy of the vital principle in such animals is, within certain limits, proportionate to the degree of warmth to which they may be subjected, and escapes in a manner the severe action of cold."[1] It is on these principles that Mr Macleay accounts for what certainly at first seems an extraordinary circumstance in the geography of insects; namely, that their tropical structure extends much farther north in America than in Europe; that is, in a manner directly the reverse of that which has been noted by botanists to occur in the vegetable kingdom. For example, the *Chamærops humilis*, a species of palm, occurs along the southern shore of France, in latitude 44°; while on the eastern coasts of North America the hardiest of the family, *C. palmetto*, does not advance beyond the 34°. But if we examine *Copris carnifex*, *Cetonia nitida*, *Rutela 6 punctata*, and other coleopterous insects from the neighbourhood of New York, and compare them with species of the same families from Brazil, we shall find their difference of structure infinitely less than that which would result from a comparison of the entomological productions of the environs of Madrid with those of the banks of the Congo.[2]

A slight consideration of the subject suffices to show that certain differences in the relative intensities of summer and of winter must exercise a strongly modifying power on the influence of mean annual temperature, even in countries where that temperature is one and the same. "Several fruits, as the olive and grape, as well as the different kinds of corn and other annuals, depend more on the heat of summer than of the whole year; while others, impatient of cold, and not requiring great heat, have their range more influenced by the temperature of winter. Now, it is almost an universal rule, that of two places whose mean temperature is the same, that nearest the sea, and more particularly a western sea, has a temperate summer and a milder winter. Hence the inland situation is better adapted to the growth of corn and fruits, the maritime one to the preservation of tender plants. In Europe, the northern boundary of the vine and olive rises as we go eastward, though in so doing we encounter a lower mean annual temperature. The *Arbutus Unedo*, *Sibthorpia Europæa*, *Erica ciliaris*, &c. rise in a westerly direction."[3] Whatever vegetation requires the absence of extreme cold rather than the presence of extreme heat, will probably extend itself in a tropical form more towards the poles on a dry continent than on a moist or marshy one. Tropical plants, therefore, will thrive better in Thibet and other inland parts of northern Asia, than they would do if transported to positions of the same latitude in America; for in the latter country the extremes of heat and cold are too distant from each other. Thus the vegetation of Canada does not correspond either in its general character or its amount of species, with that of the corresponding latitudes of France.[4]

Mr Macleay admits, that although in his opinion the insect tribes suffer less in cold climates than plants, for the reasons which we have already stated, it does not therefore follow that the prevalence of cold has no effect in relation to the destruction, or rather we should say the prevention, of insect life. In truth the diminution of the number of species becomes very conspicuous as we advance towards the poles. But this the learned author of the *Horæ Entomologicæ* supposes to be owing rather to the short continuance of the summer warmth than to the lowness of its existing degree. In accordance with this view we certainly find that many insects, such as gnats, mosquitoes, &c. which pass their larva state in water,—thus avoiding the external cold, and whose existence in the perfect state being naturally ephemeral, must therefore suffer little from the shortness of summer,—are nowhere more troublesome than among the moors and marshes of the north. On the other hand, the number of *coleopterous* species, which, being naturally longer lived, require a greater continuance of warmth, is sensibly diminished amid those dreary wastes.

It is natural to suppose that if certain plants are peculiar to certain climates, so also insects, the greater proportion of which not only feed on plants, but are each according to its kind almost restricted to particular species, must in like manner be characteristic of special localities. Whether this restriction in diet holds good in relation to the carnivorous kinds, that is, whether one kind of carcass is not as good as another, is a point which has not yet attracted the consideration of the naturalist. Such as feed on living animals (the *thalerophagous* Carnivora) are probably more restricted in their parasitical attachments. But the coprophagous or dung beetles, and such as prey on dead animals (the *saprophagous* Carnivora), may be supposed to be less regular in the limits of their localities, occurring wherever their favourite food happens (not seldom accidentally) to have been deposited. In such cases, of course, less advantage results to the entomologist from local references, as the appearance of an insect in the place cited may have been entirely accidental, and incapable of affording any great probability of its recurrence; yet even the saprophagous beetles are no doubt regulated by temperature and elevation, and it is likely that a dead body by the sea shore will exhibit different species from a similar nidus exposed on a mountain summit.

The geographical distribution of insects in general is, in truth, a subject of too difficult and complex a nature to admit of being worthily treated within our present limits. We shall, however, notice a few facts which, though presented in a somewhat desultory manner, we trust will not be found entirely devoid of interest.

We may observe, in the first place, that there are two aspects under which the subject of zoological geography may be viewed. We may either proceed upon the consideration of the divisions laid down by politico-geographical writers,—divisions which are no doubt sufficiently arbitrary in relation to the physical qualities of countries,—and describe or indicate the species and genera which we have ascertained to characterize such divisions, —or we may take into view the systematic arrangements of naturalists, and by tracing and pointing out the different localities of the various tribes, genera, and species which we find there arranged, thus arrive by another route at the conclusions sought for. We shall here, even

[1] *Hor. Ent.* p. 45.
[2] *Ibid.*
[3] Watson's *Outlines of the Geographical Distribution of British Plants.* (Printed for private circulation.) Edinburgh, 1832.
[4] *Hor. Ent.* p. 44.

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at the risk of appearing immethodical, combine, in some measure, both these processes; and while we indicate the varied localities of certain species, we shall also give an occasional sketch of the equally varied entomological productions of particular portions of the earth's surface.

We formerly remarked that no coleopterous insect was noticed in Melville Island. *Dytiscus marginalis*, however, an aquatic beetle well known throughout Great Britain, inhabits the waters of Greenland, and extends over the whole of Europe. Another species of the same genus, *D. griseus*, is not only spread over the south of Europe, and most of the countries adjacent to the Mediterranean, but is also found in Bengal. The genus *Calasoma* is very widely spread. Captain Frankland took *C. calidum* during his arctic journey. *C. laterale* and *curvipes* inhabit tropical America; while *C. Chinense*, as its name imports, is found in China. Mr Macleay possesses a specimen from New Holland; and *C. retusum* was captured in Terra del Fuego. The *Coccinellæ* occur in almost all countries from pole to pole.[1] The *Silphidæ* and *Dermestidæ* prey on carcasses wherever the solar influence is of sufficient power to produce putrescence; but the brachelytrous beetles (genus *Staphylinus*, &c.) have undoubtedly their metropolis or centre of dominion in the temperate zone, and more especially within the British islands; for while Dejean, in the last edition of his *Catalogue* (1833), gives only 789 species as his total amount both of European and exotic kinds, Mr Stephens enumerates above 750 as indigenous to Britain. This apparent excess may, however, partly arise from the great attention which has been paid in this country to the collection of the minuter sorts, which are frequently neglected in foreign lands for the sake of the more showy and imposing species. The genus *Onthophagus* is native both to the old world and the new, to the temperate as well as the torrid zone; while *Copris*, its near ally, is more abhorrent of cold,—*C. lunaris*, which extends northward into Sweden, being the only recorded species found in Europe out of Spain.[2] Latreille, however, laboured under a misconception when he supposed that all the large species of the latter genus were of equinoctial origin; for *C. Tmolus* of Fischer occurs in the vicinity of Orenburg in Asia, under the 50th degree of north latitude.[3] Of the magnificent *Dynastidæ*, termed by Mr Kirby the "giants and princes of the insect race," the metropolis is strictly tropical, although a kind of advanced piquet is observable in *Oryctes nasicornis*, common in the south of Sweden. The reason why the last-named insect, and several others which occur in Scandinavia, are unknown in Britain, may be inferred from some of our preceding observations: in a torpid state, or under the form of larvæ, they are capable of enduring the utmost rigour of a Swedish winter; but when revived by the returning spring, the cool and variable summers of our "sea-girt isle" would prove insufficient for the full development of their vital functions.

The genus *Meloe* seems almost peculiar to Europe; and Britain, which possesses nine species, has been regarded as one of its most characteristic countries. The entomological characters of the southern shores of Europe strongly exhibit their geographical approach to the African continent. The *Ateuchus sacer* (the renowned species sculptured of old by the Egyptians on their sacred monuments), and various species of *Scaurus* and *Akis*, may be regarded in the southern countries of Europe, as the *avant couriers* among the coleopterous tribes of those more exclusively African forms which have their centre of dominion in the burning deserts. Along the Mediterranean shores the entomological traveller may study the habits of many curious insects of the genera *Onitis*, *Cebrio*, *Pimelia*, *Brachycerus*, *Brentus*, and *Scarites*, and may also enrich his collection by the capture of many beautiful butterflies, and other lepidopterous insects, which are more truly characteristic of Northern Africa. Spain especially exhibits many features of African zoology. We shall not here talk of the cameleons, the scorpions, and other species belonging to the separate classes of reptiles and Arachnides; but the European entomologist will there discover for the first time several species of the genera *Erodius*, *Sepidium*, *Brachinus*, and *Pimelia*. It is however only after crossing the Mediterranean, and traversing the African shores, whether north of the Atlas, or eastward towards the coasts of the Red Sea, that our eyes are delighted with the hitherto unknown forms of *Anthia*, *Graphipterus*, *Siagona*, and numerous other species unknown to the colder and moister shores of Europe.

But no sooner do we leave the Mediterranean coasts of Africa, and enter upon the more weary and disastrous pilgrimage of the great deserts, the apparently limitless expanse of which so soon greets the eye of the yet undaunted traveller, than almost all vestiges of European life, whether human or brute, disappear; and Nubia, Ethiopia, Senegal, and a great part of Guinea, exhibit entomological forms, cognate in character when compared among themselves, but separated in every sense of the words "*longo intervallo*" from those of Europe. As we proceed farther southwards, where the chariot of the "Great Apollo" rolls on with a still fiercer and more fiery lustre, and the beams of a vertical sun induce even the tawny Moor and the woolly-headed negro to avoid his scorching and sometimes fatal rays, we discover many extraordinary forms of insect life, called into existence through the instrumentality of that bright effulgence which the pale-faced European has so often sought to withstand in vain. From the burning regions of Guinea, and the parched shores of the Congo, we derive the finest of those magnificent coleopterous insects named generically *Goliathus* by Lamarck. The western and equinoctial parts of Africa also yield us the species of *Petalocheirus* and *Enceladus*, while the Cape of Good Hope is remarkable for the genera *Anthia* and *Brachycerus*. The last-named district is almost the exclusive domain of *Manticora* and *Pneumora*; and the southern parts of Africa present us with the *Sagra*, *Diopsis*, and *Paussus*, although it may be observed that some of these also occur in the East Indies.[4]

Both Madagascar and St Helena present a few insects which, to a certain extent, demonstrate the African complexion of those islands; but the latter especially is also allied, by its entomological features, to some of the south-western countries of Asia. According to Latreille, Africa furnishes no species of the genus *Passalus*, although it is elsewhere widely distributed over America and the East Indies. The genera *Graphypterus*, *Eurichora*, and *Pneumora*, are probably peculiar to Africa. Among the hemipterous insects of Africa may be mentioned the *Mantis precaria*, an object of superstitious veneration among the Hottentots, who hold in the highest respect the person on whom the insect happens to alight. Locusts are of common occurrence in many parts of Africa, where, as "a great people and a strong," they still produce their days of "darkness and of gloominess," their days "of clouds and of thick darkness," so magnificently described by the Prophet Joel. One of the most formidable of the insect tribes of this continent is the *Termes bellicosus*, or

[1] *Introd. to Ent.* vol. iv. p. 488.
[2] *Ibid.* p. 490.
[3] *Entomographia Russica*, tab. 13, fig. 1.
[4] *Edinburgh Cabinet Library*, vol. ii. p. 93.

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white ant. It dwells in congregated troops, consisting of labourers, soldiers, and sovereigns. The habitations are of a conical form, built of mud and clay, from ten to twelve feet high, and divided in the interior by thin partitions into a variety of cells. Indeed, Jobson, in his *History of Guinea*, alleges that they are often twenty feet high; and he adds, that he frequently found them extremely serviceable in screening himself and his companions while engaged in the pursuit of antelopes and other game. The queen-mother of this species becomes of so enormous a size in the pregnant state, that her abdomen exceeds, by two thousand times, the bulk of the rest of her body; and when the ova are fully formed, she obtrudes them at the rate of sixty in a minute, or 72,000 in twenty-four hours. Madeira and the Canary Islands are decidedly African in their productions,—the insects, especially, exhibiting a strong relationship to those of Barbary and the adjacent districts.

Latreille, while considering the geographical distribution of insects, has well observed, that where the empire of Flora terminates, there the domain of zoology likewise comes to an end. Animals which feed on vegetables cannot support themselves in a region entirely sterile, and such as are carnivorous are thus themselves indirectly deprived of sustenance in consequence of the want of vegetation. Those countries of which the vegetable productions are the most gorgeous and abundant, are likewise the most productive of insect life. Both effects spring from a temperature high and continuously sustained, from moderate moisture, and a varied soil. The more closely, on the contrary, we approach the other extreme, where clouds and darkness obscure the sky, and the ground is so often covered with a pure but unproductive garment of snow, and the lifeless solitude of the mountain valleys is defended by the icy battlements of the enduring glaciers,—the more we shall perceive a diminution in the amount of organic, and more especially of insect life. If, instead of travelling northwards to the polar plains, we ascend some majestic mountain even of a tropical range, the same phenomena are observable. Although its base should be laved by the glittering waters of an equatorial sea, and its sloping sides should bear the arborescent ferns and plumy palm trees of the warmest climes,—still, should the mountain belong to the highest class, like those of Cayambé or Chimborazo, long before the traveller has approached its barren summit, he will perceive the most striking symptoms of that sterility which we are apt to associate only with the polar regions. The "bright consummate flowers" of the lower plains have disappeared,—the parrots in their gay attire no longer adorn the stunted trees,—and the insect tribes, so fantastic in their forms, and of such surpassing lustre, have gradually decreased in size and number, and at last present, in common with the vegetable kingdom, an aspect and character much more allied to those of northern climes. Finally, unless it may be that some giant condor, or other bird of loftiest flight, is seen floating in the thin air of those extremest heights, there is nothing to remind the adventurous traveller that he is actually within the *burning* tropics; for all his perceptions and sensations might be identical were he suddenly transported to the summit of Mount Hecla,

An earthquake-rifted mountain of bright snow.

It is thus that, on the Central Alps of Europe, we meet with many species characteristic of, though not peculiar to, the plains of northern countries. The *Prionus depsarius*, long regarded as exclusively confined to Sweden, has in later times been taken on the mountains of Switzerland; and M. Latreille has captured at Cantal the *Lycus minutus*, formerly received only from the most northern provinces of Europe. The beautiful Apollo butterfly (*Parnassius Apollo*), so common in the plains and flower-gardens in the vicinity of Upsal, never occurs in France, except on mountains of considerable elevation, and re-appears again in the snow-surrounded valleys of Switzerland. Many other butterflies which, in the northern provinces of France, occur not far from warm and low-lying sheltered stations, are found in the southern departments and in Italy on alpine or sub-alpine situations. The same may be said of *Carabus auratus* and *Acridium grossum*. Even in Great Britain, the limited extent of which might be supposed to preclude any great disparity in the entomological productions of its geographical divisions, there is an obvious difference between its southern and northern quarters. The colder and more cloudy clime of Scotland is poor in Lepidoptera of the finer kinds. Here no purple emperor, "proud of cerulean dyes," floats over the far-stretching branches of our oaks and beeches,—no swallow-tailed butterfly (*Papilio Machaon*), with its elegantly lengthened wings, reminds us of the exquisite Brazilian tribes,—no "Camberwell beauty" (*Vanessa Antiopa*) expands to the sun its richly margined wings; but these and many more, denied to bleak Caledonia, are found in the southern counties of England.[1] It is interesting, however, to observe the analogy which exists between the insects, more especially the Coleoptera of Scotland and of Sweden. Several of the rarest species lately discovered in the northern quarters of the island, such as *Clivina Arctica*, *Harpalus micropterus*, *Elaphrus Laponicus*, *Byrrhus æneus*, *Salpingus foveolatus*, and others, are better known in the Scandinavian peninsula than elsewhere, and are indeed characteristic of the north-western division of the continent of Europe.

From these and similar observations, those who have viewed the science of entomology with a philosophic eye have endeavoured, in common with geographers, to divide the surface of the earth into different climatic regions. But while the latter have assumed as a basis the progressive differences in the longest continuance of the natural day, the former proceed upon a knowledge of the mean temperature of countries. Fabricius, in his *Philosophia Entomologica*, divides climate in general into eight subclimates, or restricted stations, viz. the *Indian*, the *Southern*, the *Mediterranean*, the *Northern*, the *Eastern*, the *Western*, and the *Alpine*. But it is easy, as M. Latreille has remarked, to perceive, by the enumeration of the particular countries which are referred to each of these divisions, that the divisions themselves are by no means established on a fixed foundation; and that the suppression of several would be necessary were the principle on which they are established followed out with rigour. The subclimate which he names *Mediterranean* comprises the countries adjacent to the Mediterranean Sea, with Media and Armenia. The *Northern* extends from Paris to Lapland. The *Eastern* consists of the north of Asia, of Siberia, and of the cold or mountainous portion of Syria. The *Western* contains Canada, the United States, Japan, and China. From these it will be seen that this arrangement is in many respects extremely arbitrary; for several of the above-named districts, although placed under separate climates, have a mean temperature identically the same. Moreover, many countries in which the mean temperature is the same, are characterized and distinguished

[1] On the other hand, *Hipparchia Blandina* and *Lycæna Artaxerxes*, two extremely rare English butterflies, occur very plentifully in many parts of Scotland,—the former in July and August, the latter in June and July.

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by a great disparity in the nature of their animal productions.

M. Latreille has taken another view of this interesting subject, more in conformity with the dictum of Linnæus, regarding the characters of genera, the spirit of which may be also here applied. "Let the insects point out the climate, and not the climate the insects." He takes into consideration all those genera which seem to be appropriated exclusively to certain determinate spaces on the surface of our earth. It is true that the groundwork of this method is much more restricted than that from which Humboldt and other writers on botanical geography have deduced their observations on the distribution of plants; for our knowledge of the precise localities of foreign insects is by no means ample.[1] The great French entomologist rather upbraids the majority of scientific travellers with their negligence in these particulars; for it is not the locality alone, but the physical character of the climate, the mineralogical qualities of the soil, the vicinity of wood and water, and the height above the level of the sea, which ought to be noted in connection with the occurrence of particular species. We have already noticed the fondness of *Papilio Cleopatra* and other insects for a calcareous soil. The *Pimelia bicaudata*, so common in the neighbourhood of Marseilles, scarcely ever occurs at a distance from the sea. If the interior parts of Barbary, Syria, and Egypt, present us with species of the same genus, this entomological relation no doubt results from the soil of these countries being impregnated with saline particles, and abounding in plants of the genus *Salsola*. The insects which occur in the countries which border the Mediterranean, the Black, and the Caspian Seas, exhibit many analogies.

The following propositions result from M. Latreille's researches in Entomology.

1*st*, The totality or a great proportion of the insects which occur in countries of which the qualities of the soil and temperature are analogous, are nevertheless of different species, if these countries, though placed under the same parallel, are widely distant from each other. All the insects brought from the most eastern parts of Asia, for example China, are distinct from those of Europe and of Africa, whatever may be the latitude, elevation, or mean temperature of these Asiatic countries.

2*d*, The generality of insects still differ specifically in countries agreeing in the characters of their soil and temperature, but separated, independently of mere latitudinal difference, by great natural barriers, such as chains of lofty mountains, vast sandy deserts, or the waters of an intervening ocean. Thus the species of New Holland or of America are easily recognised among those of the various countries of the ancient world; and even the insects of Grenada and Peru, though at no great distance from those of Guiana, are in a great measure different, owing no doubt to the interposition of the vast chain of the Cordilleras. When we pass from Piedmont into France by the Col de Tende, we perceive a marked difference of species, even in that short journey. These rules, however, like most others, however general, are subject to several individual exceptions. Several species of insect are distributed over such a vast extent of territory as entitles them to be regarded as genuine cosmopolites. Thus the painted lady-butterfly (*Vanessa Cardui*) is found over great portions of Europe, Asia, Africa, and America, and is as familiarly known in the central islands of the vast Pacific Ocean, as in the flower-gardens of England.[2] That beautiful sphinx-moth (*S. nerio*), well known near Genoa, and so remarkable for the richness of its *green*, a rare colour among lepidopterous species, although it seldom occurs farther north than France, is found in the Mauritius, and probably in many intermediate countries. The deaths' head moth (*Sphynx Atropos*), which occurs occasionally in most parts of Scotland, is well known in India and the Isle of France. We have already mentioned the great extent of territory occupied by several aquatic beetles; and these and other examples which might be adduced remind us of M. Latreille's next proposition.

3*d*, Many *genera* of insects, and particularly such as feed on vegetables, are spread over numerous points of the principal divisions of our globe.

4*th*, Other genera are exclusively proper to a certain extent of country, whether of the ancient continents or the new. According to Latreille, no species of the genera *Anthia*, *Graphipterus*, *Erodius*, *Pimelia*, *Scaurus*, *Cossyphus*, *Mylabris*, *Brachycerus*, *Nemoptera*, *Apis*, or *Anthophora*, occur in America; and many genera of the family *Scarabeidæ* are likewise there unknown. But the western world, on the other hand, produces several genera which we do not meet with elsewhere,—such as *Agra*, *Galerita*, *Nilio*, *Tetraonyx*, *Rutela*, *Doryphora*, *Alurnus*, *Erotylus*, *Cupes*, *Corydalis*, *Labidus*, *Pelicinus*, *Centris*, *Euglossa*, *Heliconia*, *Erycina*, *Castnia*, &c. Our bees are there replaced by *Melipona* and *Trigona*. We have already mentioned several genera peculiar to Africa. *Colliuris* is characteristic of the East Indies; *Lamprima*, *Helæus*, *Paropsis* (*Notoclea* of Marsham), and *Panops*, are confined to New Holland.

5*th*, Many species in their natal countries effect particular localities. Several alpine butterflies are never observed at any considerable distance from the region of perpetual snow, while other species prefer the warmer air of low-lying sheltered meads at no great height above the level of the sea.

6*th*, Both the ancient continent and the new may be divided into zones, successively extending in the direction of the meridians, and the breadth of which is measurable by a portion of a circle parallel to the equator. The species proper to one of these zones disappear gradually, and give place in the same manner to those of the zone following; so that from space to space the dominating species, or even the totality, have undergone a change.[3] Latreille compares these changes to that series of horizons which the traveller discovers in proportion as he removes from his first point of departure.

Sweden presents us with many insects peculiar to that country, some of which are confined to its more northern provinces, such as Lapland. But its southern portions, for example Scania, produce, though still in limited numbers, many German insects. France, as far as the 45th or 44th degree, supplies the entomologist with many of the species which occur in the last-named countries; but the Rhine and its eastern mountains form a kind of frontier line, which many others do not appear to pass. The first of the species characteristic of the warmer regions of

[1] The second edition of Comte Dejean's *Catalogue de Coléoptères* now exhibits a very interesting picture of the distribution of that order. We shall refer to it more particularly when we come to treat of the coleopterous tribes.

[2] *Edinburgh Review*, vol. liii. p. 339.

[3] *Introduction à la Geographie Générale des Arachnides et des Insectes, ou des Climats propres à ces Animaux.* This memoir was read to the Academy of Sciences in 1815, and forms part of the 3d volume of the *Mémoires du Muséum d'Hist. Nat.* It was afterwards republished, with corrections and additions, along with some other essays, in a separate volume, entitled *Mémoires sur divers Sujets de l'Histoire Naturelle des Insectes*, &c. Paris, 1819.

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Western Europe show themselves towards the inferior course of the Seine, in pretty close accordance with the point where the vine is vigorous in the open air, independent of any succour derived from merely local circumstances. *Ateuchus flagellatus, Mylabris chicorii, Mantis religiosa, Cicada hæmatodes, Ascalaphus italicus,* and others, announce this change,—which becomes still more obvious at Fontainebleau and the environs of Orleans, where, in addition to the above-named species, we may perceive *Phasma Rossii, Mantis pagana,* and *Sphinx celerio.* But these are but the forerunners of such as are native to southern countries properly so called. The culture of the olive, the spontaneous growth of the Arbutus, the pomegranate, and of lavender, are botanical symptoms which cherish in the mind of an instructed entomologist the hopes of a rich increase. This change is very obvious in France, when, journeying from Paris to Marseilles, we reach the territory of Montélimart. The eastern provinces of Spain, those sunny regions where the orange and the palm-tree are luxuriant without the aid of man, produce more abundantly the rarer southern insects of France, intermingled with species hitherto unperceived in Europe.

Our knowledge of the insects of the south-east of Europe is by no means ample. Latreille informs us that the *Papilio chrysippus* of Linnæus, common in Egypt and the East Indies, makes its first appearance as a European species in the kingdom of Naples. The greater proportion, however, of the Egyptian species are entirely unknown in Europe, although they pertain, in numerous instances, to the same natural families as our own. The southern parts of that land of pyramids produce many magnificent species of *Copris,* such as *C. Midas, Bucephalus, Antenor, Gigas,* and other insects peculiar to warm countries, and seldom found at any great distance from the equinoctial line of the old continent.

Similar successions of species take place from east to west, and reciprocally. Most of the insects which occur in Normandy and Brittany likewise inhabit the southern parts of England. The northerly departments of France, situated on the banks of the Rhine, have in many respects a community of species with the neighbouring provinces of Germany; while, again, several species of the Levant, such as *Cantharis orientalis, Mylabris crassicornis,* a beautiful variety of *Melolontha occidentalis* brought home by Olivier, and certain diurnal Lepidoptera, appear to have journeyed far westward from their ancestral homes, and fixed their abode in the Austrian territory. The collections formed by Olivier in Asia Minor, Syria, and Persia, prove that the insects of those countries, though nearly related to those of the south of Europe, are not specifically the same; and a like judgment, with some exceptions, may be entertained of the species of Southern Russia and the Crimea. The entomological productions of the coast of Coromandel, of Bengal, of the south of China, and even of Thibet, possess many characters in common; but they are entirely distinct from those of Europe. In the regions just named we discover no species of the genera *Graphipterus, Akis, Scaurus, Pimelia, Sepidium,* or *Erodia,* for of these nature appears to have granted the exclusive possession to the south-western regions of the ancient continent. Although Fabricius assigns the East Indies as the native country of certain species of *Brachycerus,* Latreille has been unable to identify any from such locality. The genus *Anthia* is said to occur in Bengal, but not farther eastward.

The great Asiatic division of our globe, when considered in its entomological and other zoological relations, may indeed be partitioned into several different departments.[1] The Siberian or most northern portion, in consequence of the severity of its winter season, possesses, even in its southern districts, many attributes of the arctic regions; while its inland valleys, and the upper basins of its numerous and far-flowing rivers, are enriched, during a brilliant though short-lived summer, with many of the more gorgeous forms of insect life. Another vast and imperfectly known region of Asia is bounded to the north by Siberia, and to the south by those highly elevated table-lands which terminate among the Himalaya Mountains. This division still presents several features which prove its assimilation in some respects to the characters which distinguish animal life in Europe; for although it is undoubtedly characterized by numerous peculiar forms of existence, yet many of its genera and species are either the genuine types of groups which occur in countries with which we are familiar, or pertain to groups which are themselves well exemplified by European insects. But we now speak rather in relation to the higher animals than the insect tribes; for, in truth, of the Entomology of Central Asia we have as yet a most inadequate idea. Among the Himalaya Mountains, and other southern portions of this division, we begin to discover many genera of birds which occur in the lower lands of Hindustan and the peninsular projection of Malacca; and if the entomological kingdom is at all regulated by corresponding rules, we may infer that some of the southern insects also make their way up those stupendous valleys. The same circumstance indeed occurs, we mean the like transition of species, in all the great geographical sections of the groups of animal life. "Each extensive division is characterized by several peculiar forms, and yet at the same time nourishes many species which are common alike to it and to other regions; and it is only under some peculiar circumstances of local situation, that either the zoological or botanical products undergo a sudden change in character and condition. As the adventurous and observant traveller advances on his journey, a few species are continually perceived to decrease in number, and then to disappear, while their places are supplied by others, which, at first but thinly scattered, gradually acquire an accession of numbers, till they too have reached their full amount or centre of dominion; but the change being only partial from place to place, the difference is no more suddenly perceptible than that in the horizon by which the traveller is surrounded, and a portion of which in his onward progress becomes insensibly, from the circumference, the very centre of the field of vision."[2] But no sooner do we enter upon the zoology of India Proper, than the European forms of animal life almost entirely disappear, and are succeeded by others of a richer and more varied character of form and aspect, some of which, however, extend to the parallel latitudes of the African continent. The Asiatic Islands again present us with another picture, and this latter change may be said to commence at the southern extremity of the Isthmus of Malacca. Java and Sumatra, in Mr Swainson's opinion, will probably be found to be the metropolis or central region of this range, which still produces several of the forms of Northern India; while in New Guinea and New Ireland, the Asiatic forms properly so called begin to disappear, and are replaced by many singular and interesting species, which exhibit the commencement of what may be termed the Australian kingdom. *Papilio bolina* occurs both in Java and New Holland.

Madagascar, as might be supposed, exhibits in its natu-

[1] *Edinburgh Cabinet Library,* vol. viii. p. 1.

[2] *Ibid.* p. 2.

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ral families a resemblance to Africa. Nevertheless the species are distinct, and many of them present no analogy whatever to those of the continent. The Isles of France and Bourbon likewise manifest traces of the same family resemblance; but, on a general view, they show a closer connection with the East Indian species. Their ascertained number is, however, extremely limited.[1]

Although the Entomology of New Holland may be said, like that of all other vast tracts of country, to exhibit a special type, it is yet composed, in some of its principal portions, of species analogous to those of the Moluccas and the south-east of India. This great fifth continent, as it has been called, is, however, less rich in insects than many other foreign countries, its soil being drier, and not so well wooded. The genus *Mylabris*, so abundant in the south of Europe, in Africa, and Asia, does not appear to pass beyond Timor. In that respect, then, New Holland agrees with America, as well as in the possession of *Passalus*, a genus of which the species have been more particularly noted as inhabitants of the new world. Several generic groups of the latter region present a closer resemblance to those of the east of Asia, than to such as are characteristic of the ancient world. The insects of New Zealand, of New Caledonia, and the circumjacent isles, show an obvious relation to those of New Holland; and the same may be said of such as occur in the archipelagos of the Great Southern Ocean. These islands, composed in great measure of aggregations of polypiferous rocks, form a chain which unites them in a westerly direction to the preceding regions, and from which many of their natural productions may have been received in the long course of ages. This natural communication could not have taken place with the new world, and thus many of these islands, although rather American than otherwise, according to their geographical position, may be regarded as Asiatic in regard to their animal and vegetable products.

The new world has also been observed to present progressive changes in the succession of its species, in connection with every considerable difference in the latitude and longitude. M. Bosc collected in Carolina many species which were unknown in Pennsylvania, and were still more foreign to New York; and the researches of Abbot in illustration of the Lepidoptera of Georgia demonstrate the existence in that province of certain species which have their central station in the Antilles. The banks of the far-stretching Missouri, about twenty degrees to the west of Philadelphia, produce many peculiar species. The Entomology of the Antilles presents a strong contrast to that of the United States. Trinidad, under the tenth degree of north latitude, presents us with truly equatorial species, such as the splendid butterflies called Teucer and Menelaus, which do not occur in St Domingo. Brazil, so gorgeous in its insect tribes, possesses species in common with Cayenne, but it also produces many others peculiar to itself. Latreille differs from Mr Macleay in his opinion regarding the comparative extension, in a northerly direction, of the southern species in the new and old world. He states that the southern species of the western hemisphere do not attain to so high a latitude as they do on the ancient continents. Here, he thinks, they begin to appear between the forty-eighth and forty-ninth degrees of north latitude; there, not until we gain the forty-third degree.[2] In relation to this subject Mr Kirby has remarked, that although the winters in Canada, within the same parallel as France, are longer and more severe than those even of Great Britain or of Germany, yet the summers are intensely hot; so that though tropical *species* do not range so high, those of a tropical *structure*, in conformity with Mr Macleay's views, may be found in a higher latitude in the new world than in Europe.[3] When we take into consideration certain peculiarities in the physical constitution of America,—its well watered surface, its lofty mountains, its majestic forests, and humid atmosphere,—we shall easily understand how many genera of the ancient continent, dwelling by preference in dry, warm, and sandy situations, for example *Anthia*, *Pimelia*, *Erodius*, and *Brachycerus*, should not occur in the comparatively rich, moist, and shaded soils of the new world. Thus also the carnivorous Coleoptera in America are proportionally of smaller amount than in the old continent, although no quarter of the globe is more productive of large and splendid species among the phytophagous or vegetable-eating tribes of insects. However, the south of China and the Moluccas still maintain a certain superiority in the production of such splendid examples of the lepidopterous order as *Papilio Priamus* and *Bombyx Atlas*, of which the dimensions surpass those of the American species. A fact noted by Latreille is worthy of remembrance, viz. that Europe, Africa, and Western Asia, are extremely unproductive of the genus *Phasma*, or the spectre insect, and that such of the species as do occur are extremely small, while the Moluccas and South America produce many of remarkable size. The atmospheric humidity of the new world, its narrow and elongated form, the nature of its soil, and the vast extent of ocean by which it is environed, are sufficient reasons for the disagreement observable between its productions and those of corresponding latitudes in our own hemisphere. The new world, in fact, bears in many respects the same relation to the old that Britain does to a great portion of Europe.[4]

We have already alluded to the classification of climate given by Fabricius, and to certain circumstances which have been supposed to render the adoption of that classification unadvisable. Latreille has viewed the same subject under a better aspect. He considers the northern extremities of Greenland and of Spitzbergen, under the eighty-first degree of northern latitude, as the points where vegetation terminates. But to obviate all difficulty, and with a view to establish a duodecimal division, which is not only convenient in itself, but also in frequent accordance with the actual observation of geographical groups, he raises this supposed limit of vegetation three degrees higher, that is, to the eighty-fourth degree. If we then divide into successive spaces of twelve degrees, a meridian commencing from the western parts of Spitzbergen, or those nearest to Greenland, we shall have a suite of latitudes corresponding successively to the limits of the countries already alluded to in relation to their zoological productions. He continues these sections duodecimally or by twelve degrees, beyond the equator, and towards the antarctic pole, and stops about the sixtieth degree of southern latitude, under the parallel of Sandwich Land, regarded in that direction as the *ne plus ultra* of geographical discovery.

It appears that a difference in latitude of twelve degrees always produces a very sensible change in the mass of insect species; and that if that space is doubled, the alteration is almost total; as, for example, between the

[1] See an interesting memoir (which we did not receive till the present pages were in types, and which we consequently have not had time to analyse) entitled "Sur les Lepidoptères de Madagascar, Bourbon, et Maurice," by Dr Boisduval, in the *Nouvelles Annales du Muséum*, t. ii. p. 149.

[2] *Mémoires*, p. 182.

[3] *Introd. to Entomology*, vol. iv. p. 492.

[4] *Mémoires*, p. 184.

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north of Sweden and the north of Spain. An analogous change takes place in relation to the *longitude*, but more slowly, and after a traverse of a greater distance; since the mean temperature, but for causes of a particular and local nature, is not widely different under the same parallel. In proportion as we approach the pole, the extent occupied by particular races embraces a greater number of geographical divisions.

The insects of America, even those of its northern provinces, at least as far as Canada, may be said to differ specifically from those of Europe; but the species of Greenland may rather be regarded as European. The last-named country, so far as the entomological geography of the ancient continent is concerned, is assumed by Latreille as the point of departure for his first meridian. In any view it may be regarded as intermediate between the two hemispheres. The Canaries, the Cape de Verd Islands, and Madeira, are African, judging from their entomological productions. The meridian above named will thus follow a middle line between these islands and the most eastern cape of South America, that of St Roque, near Rio Grande, in Brazil. It will pass by the western isles, or archipelago of the Azores, and by the island of Ascension, and will abut to the westward of Sandwich Land. Its longitude will be thirty-four degrees to the west of the meridian of Paris. According to Latreille's observations on the insects collected by Olivier in Persia, their general relationship to those of the south of Europe and the north of Africa, and the essential differences which they present when compared with the entomological productions of the East Indies, it may be inferred that the most signal changes in the species take place in a southerly direction towards the frontier lines of Persia and Hindustan, and in a northerly direction at a short distance from the eastern slopes of the Uralian Mountains and Lake Aral, a little beyond the sixtieth meridian east of Paris. We may fix this limit approximately at sixty-two degrees, somewhat to the west of the Obi, and of Balk and Candahar, for the sake of affording the means of continuing a duodecimal division; for if we add 62 to 34, the difference between the first meridian and that of Paris, we have the number 96, a quantity susceptible of being divided, without fractions, into eight parts, each equal to the thirtieth portion of the circle. We thus separate the ancient continent into two great bands, of which one is western and the other eastern; and if we assign to the latter the same extent in longitude as the former, that is, ninety-six degrees, it will terminate 158 degrees of eastern longitude from the meridian of Paris. Departing from Kamtchatka, it will pass by the Carolinas, and from thence between New Holland and New Zealand. If augmented by one fourth, or by twenty-four degrees, this eastern band would be bounded by the 182d meridian east of Paris, and passing at a short distance from East Cape, over Behring's Straits, would stretch beyond the Friendly Islands, and form, without any material error in relation to our entomological views, a line of demarcation between Asia and America. The remaining 144 degrees complete the equatorial circle, and compose the extent in longitude of that great zone proper to the insects of America. It may also be divided, and under the same denominations of eastern and western, into two equal portions, each of seventy-two degrees. Thus the entire circle of the equator may be regarded as divisible into four arcs, of which the values are, 72, 72, 96, and 120, or in the proportion of six thirtieths, eight thirtieths, and ten thirtieths. The extent in longitude of the ancient continent will comprise 216 degrees, and that of the new 144.

The lesser zones or climates are denominated *arctic* or *antarctic* by M. Latreille, according to their position on this or the other side of the equator. The climate included between the 84th and 72d degrees of north latitude is named the *polar* climate. Then follow as far as the equator, and always in divisions of twelve degrees, the following climates, viz. the *sub-polar*, the *superior*, the *intermediate*, the *super-tropical*, the *tropical*, and the *equatorial;* and as each hemisphere is partitioned into two great divisions, the climates of each are distinguished by the name of western and eastern. The antarctic climates consist of only three in number, as we know little of what exists amid those chilly regions beyond the 60th degree of south latitude, and thus in that direction both the polar and sub-polar climates may be suppressed. We shall illustrate these views by a few applications to the northern and western kingdoms of Europe, the best known portions of the old world.

The *polar* climate presents us with the insects of the greater part of Greenland, and with those of Iceland and of Spitzbergen. In the *sub-polar* climate we shall find those of Norway, of the north of Sweden, and of Russia in Europe. These two of course contain the insects of the coldest climates of the earth. We may regard as belonging to the *superior* climate the species of Great Britain, of the south of Sweden, of the north of France as far as the inferior course of the Loire, of Prussia, of Germany Proper, and of the south of Russia as far as the Crimea exclusive. The *intermediate* climate, at equal distances from those of the equator and the pole, will comprehend all the species of the south of Europe, and of a portion of the west of Asia. Those of the north of Africa, and as far as the equator, may be classed under the climates called *super-tropical*, *tropical*, and *equatorial*. These western climates may be divided into two equal parts, each consisting of forty-eight degrees, by a meridian which, passing fourteen degrees to the east of Paris, in the vicinity of Vienna, would leave to the east the most southern part of Italy, Turkey in Europe, Egypt, &c. Now it has been already remarked, that many of the insects of the environs of Vienna are also known to occur in the Levant, and that those of the kingdom of Naples, of Egypt, and of the south-east of Europe, appear to differ in many respects from the southern and western species of that division of the globe. We can here, then, effect the formation of sub-climates. If we divide the eastern portion, of which the extent in longitude is 120 degrees, into four equal sections of thirty degrees, by meridians, we shall have sub-climates, of which the boundaries seem very accordant with nature. Thus the first would comprehend Hindustan, Thibet, Little Bucharia, &c. while the second would detach almost all the Philippine Islands, China Proper, and the regions of the north as far as a short way beyond the river Lena. Corea, Japan, and the countries of the Manchous and Tongouses, &c. would form the third subdivision. The fourth would present Kamtchatka, and the other countries which terminate the north-east of Asia. America may likewise be subdivided after a similar manner.

It must, however, be borne in mind that nature, in her distribution of the localities proper to the various races of animals, often swerves from her more regular and accustomed courses, and that the *lines of habitation* form numerous curves and sinuosities, not unfrequently crossed or interrupted by others of a somewhat different nature. We must, therefore, in considering such views as the preceding, make abstraction of particular modifications which alter or derange our theoretical views. Latreille's is but an unfinished sketch of a highly interesting geographical map of Entomology, in which he has endeavoured, as well as he could, to mark out various boundaries, and to divide them according to certain principles in harmony with his

actual observations, so far as these have been hitherto carried. The geographical distribution of living beings presents a wide field for speculation, although the modes by which that distribution has been effected will probably in many cases remain for ever concealed from human knowledge. Their gradual extension by natural means, from a single centre of creation, scarcely falls within the sphere of credibility; and thus the creation of various groups of species over different points of the earth's surface, and in accordance with the climate and physical character of different countries,—or the removal and dispersion, by supernatural agency, of the greater proportion of existing species from an original centre,—seem the two points, one or other of which remains to be illustrated by whoever is curious in such bewildering speculations. "A glance at the innumerable and far-spread legions which compose the busy world of insect life renders the subject still more complex and confounding. A discovery ship, under the guidance of brave men, surmounts with difficulty the terrors of the ocean; and, after being months on the trackless main, and some thousand miles from any of the great continents of the earth, she arrives at last and accidentally at some hitherto unknown island of small dimensions, a mere speck in the vast world of waters by which it is surrounded. She probably finds the 'Lord of the Creation' there unknown; but though untrod by human footsteps, how busy is that lonely spot with all the other forms of active life! Even man himself is represented not unaptly by the sagacious and imitative monkeys, which eagerly employ so many vain expedients to drive from their shores what they no doubt regard as merely a stronger species of their race. 'Birds of gayest plume' stand fearlessly before the unsympathizing naturalist; and at every step of the botanical collector the most gorgeous butterflies are wafted from the blossoms of unknown flowers, and beautify the 'living air' with their many splendid hues. Yet how frail are such gaudy wings, and how vainly would they now serve as the means of transport from that solitary spot, where all the present generations have had their birth! In what manner, then, did they become its denizens, or by what means were they transported to a point almost imperceptible in comparison with the immeasurable extent of the circumjacent ocean?"[1]

In the opinion of Humboldt, the causes of the distribution of species, whether in the vegetable or in the animal kingdom, are among the number of mysteries to which natural science cannot attain. This science, or at least that branch of it which takes cognizance of zoological geography, is not occupied in the investigation of the origin of beings, but of the laws in accordance with which they are now distributed over the surface of the earth. It enters into the examination of things as they are, the co-existence of vegetable and animal forms in each latitude, at different heights, and at different degrees of temperature; it studies the relations under which particular organizations are more vigorously developed, multiplied, or modified; but it approaches not problems the solution of which is impossible, since they touch the origin or first existence of the germs of life. "We may add," says that enlightened naturalist, "that the attempts which have been made to explain the distribution of various species over the globe, by the sole influence of climate, date at a period when physical geography was still in its infancy; when, recurring incessantly to pretended contrasts between the two worlds, it was imagined that the whole of Africa and of America resembled the deserts of Egypt and the marshes of Cayenne. At present, when men judge of the state of things, not from one type arbitrarily chosen, but from positive knowledge, it is ascertained that the two continents, in their immense extent, contain countries that are altogether analogous, and that there are regions of America as barren and burning as the interior of Africa."[2] It is indeed true that the migration and distribution of organized bodies can no more be solved as a problem in physical science than the mystery of their original creation; and that "the task of the philosopher is fulfilled when he has indicated the laws in accordance with which nature has distributed the forms of animal and vegetable life."[3]

In regard to those exquisite tribes which form the more immediate subjects of our present observations, it is known that the increasing intensity and continuance of heat exert a powerful influence on the size, structure, and external adornment of the species. The nearer, in general, that we advance towards equinoctial countries, the more remarkable do we find these creatures, for their largeness of dimension, their singularity of form, and their depth as well as splendour of colour. An accurate knowledge of the distribution of insects is of the highest interest to the geologist and geographer as well as to the entomologist, and may be the means of determining, in doubtful or disputed cases, the natural and what may be called the original limits of countries; as, for example, in the case of islands situated at nearly equal distances between two distant continents. But we cannot here pursue the subject under a more extended form.[4]

Having thus cursorily considered the geographical distribution of insects, we may now devote a brief space to their *local* distribution, or favourite haunts, according to their kind, in any given district. The surface of a country, it has been observed, consists either of mountains, hills, and valleys, or of plains. In either case it may be bare and exposed, or diversified by forests, groves, or copses; and it may also be dry and sandy, or rich and well watered by lakes and rivers. Such parts as are uncovered are greatly varied by the hand both of art and nature, and present heaths or grassy downs, marshes, meadows, or tillage land, each of which is characterized by a difference of soil as well as of vegetable surface. In each the careful entomologist will discover peculiar kinds of insects. "As mountains and hills have usually their own Flora, the insects appropriated to alpine plants can only be met with where their pabulum is found. Here also those northern insects that are impatient of a warm climate will take their station if they migrate to the southward. The predacious beetles likewise sometimes frequent a mountainous district. *Carabus glabratus* was first taken by Professor Hooker on Ingleborough; and probably, if the Welsh and Scotch mountains were duly investigated by an entomologist, many novelties would reward his toils. The valleys and plains, especially those of a sunny exposition, abound in insects. When the heat of the atmosphere indisposes you for motion, you will find it no unprofitable or unpleasant employment, lying on the grass, to search for minute beetles, which you will there find coursing about amongst the tufts and roots of the herbage. Thus you may procure many of the *Pselaphidæ*, which you would not otherwise meet with. Even when the grass is grown up, insects are fond of alighting upon

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[1] *Edinburgh Review*, vol. liii. p. 334. [2] *Personal Narrative*, vol. v. p. 180. [3] *Ibid.* vol. iii. p. 496.

[4] In addition to the works already mentioned, the reader may consult an excellent *Essai sur les Coleoptères de la Guyane Française*, par M. Th. Lacordaire, in the Nouv. Annales du Muséum, t. ii. p. 35; and *Thoughts on the Geographical Distribution of Insects*, in the 6th No. of the *Entomological Magazine*.

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its spikes, and thence drop or run to the ground. Should circumstances ever carry you abroad to the steppes or grassy plains of Tartary, or to Hungary, you will find there two or three species of the singular genus *Lethrus*, which burrows in the soil. Every hole is inhabited by a male and female;—from it they issue to attack the plants or vines; and having cut out the heart of a plant, go backwards like a crab with the prize to their burrow. At the time of pairing, sometimes violent battles, encouraged by the female, take place between the male and a stranger of that sex desirous of admission, which cease only with the death or flight of the stranger. The vicinity and borders of *woods* generally abound in insects of every order, and, if you proceed as hereafter directed, will furnish you with numerous prizes, especially of Lepidoptera. Here alone you can meet with the purple emperor butterfly (*Apatura Iris*); and if properly equipped you may readily secure him."[1]

The aquatic beetles of the genera *Dytiscus*, *Colymbetes*, &c. of course occur in the water. During the evening twilight, however, they frequently leave their moist abodes, and wing their way over the adjacent country. When surprised, after their nocturnal adventures, by the rising sun, they will plunge into whatever water is nearest at hand, and thus rain barrels and washing tubs are sometimes not looked into in vain. Chance often throws into the hands of an entomologist what he has long sedulously sought for without success; and an open window and a lighted candle will sometimes procure what a traverse through the forest, worthy of a North American Indian, would not have obtained. By collecting aquatic plants, duckweed, and "the green mantle of the stagnant pool," and afterwards examining these productions at leisure in a basin of water, many valuable insects of the minuter kinds may be procured. Although the *Gyrinus Viola aquatica* is said to inhabit salt water, that element may be regarded as decidedly adverse to insect life. Brackish water, however, produces several peculiar species, such as *Hydræna marina*, and the large-eyed Cimicidæ. According to Latreille, the genus Pimelia occurs only in soils impregnated with saline particles, or where the genus *Salsola* abounds.

Heaths, though in a general view unproductive of insect life, yield some very beautiful species, such as *Carabus nitens* and *arvensis*, and *Cicindela sylvatica*. In regard to *soils*, such as are light, according to Mr Kirby, are most prolific in insects. Warm sandy banks are frequented by *Cicindela campestris*, *Opatrum sabulosum*, *Helops quisquilius*, &c.; and chalk is extremely attractive. The *Licini*, *Papilio Cleopatra*, several species of *Dasytes*, and *Lamiæ*, seem to delight in the latter substance. Many others are found in chalk-pits, which Mr Kirby does not think should be regarded actually as chalk insects; but rather that they simply fall into the pits, and then become more discernible in consequence of the stronger contrast of colour. By watching in one of these pits during a warm day, vast numbers of insects may be taken. Of all soils *clay* offers the fewest inducements to the entomologist.[2]

Old trees, felled timber, and planks which have lain long upon the ground, should be carefully examined by the collector, as on the under sides of the latter, as well as beneath stones, many species seek repose and shelter. Thorn and other fences, whether dead or living, are very productive; and gates, posts, and wooden rails, ought in no-wise to be neglected. Although the *sea* itself, according to the authority last quoted, produces no true insects, yet many and varied tribes are known to haunt its shores. On the sand hills of the Norfolk coast Mr Kirby found *Ægialia globosa* and *Cicindela hybrida*. *Rynchænus horridus* likewise inhabits thistles growing near the sea. Fuci and other marine rejectamenta, which border the margins of friths and estuaries, produce peculiar species of *Cercyon*, some *Aphodii*, and many *Staphylinidæ*. That singular insect *Oxytelus tricornis* has been captured in a situation like that now indicated. The inundations of rivers in spring, summer, and autumn, sweep innumerable insects from their hiding places; and when the waters begin to subside, the examination of the floating grasses, broken twigs, and various debris which line the indented shores, will afford an ample field for the investigations of the entomologist. To him indeed the most barren scene, whether of dreary moor or desolate mountain, can never be devoid of interest,—for the more untrodden the path the stronger and more rational are his hopes of becoming possessed of some of those treasures which are everywhere scattered over the wilderness of nature,—hitherto unperceived perhaps by human eye, but nevertheless performing an essential part in the great and solemn mystery of creation.

The geological relations of insects do not appear to have attracted the notice of naturalists,—we mean their more direct connection with rocks, independent of that intermediate relationship which results from the dependence of particular plants on certain soils, and the known alliance of many tribes of insects with peculiar forms of vegetable life. Mr Wailes always found the larvæ of *Enicoceri* on rough slimy stones, and he found it as great a waste of time to look for them on a smooth limestone, as to turn up a fragment of basaltic rock (whinstone) in search of geodephagous insects. The repugnance of beetles to basalt he had previously noticed. The subjacent rock of the wild district of Teesdale is almost exclusively composed of the basalt of the great whin-sill, the formation of which is regarded as a knotty point by geologists. Of course the loose and superficial stones of the country are its fragments, and among these scarcely a beetle is to be found, except a few which are superlatively common elsewhere, though *inter rariores* in the district referred to. "So far," says Mr Wailes, "as my observations, whether confined to single stones, or extended over a whole district, go, any place having limestone, particularly the magnesian, for its subjacent stratum, will afford abundance of the *Geodephaga*, as well as most other Coleoptera, whilst they will be found very thinly scattered over a basaltic region. It is strange to notice the almost uniform absence of these insects on turning up a whin which has accidentally found its way into a heap of other stones, though every one of the latter may have one or more tenants under it. Must we not look to the comparative dryness of the limestone and humidity of the whin for an explanation? We can readily account for the great predominance of the land *testacea* on a limestone district; but lime does not enter into the composition of beetles."[3]

Insects may also be viewed in relation to their seasons of appearance, or the most appropriate periods for the collection of the different kinds. Such as gather honey and the pollen of plants are among the first to proclaim the approach of spring; and their appearance may be dated from the blossoming of certain trees and flowers of common occurrence. Other plants, likewise accompanied

[1] *Introduc. to Ent.* iv. 499.

[2] *Ibid.* p. 304.

[3] *Entomological Magazine*, iii. 257. For a correct chemical analysis of the constitution of insects see page 29 of this volume of the Encyclopædia.

by peculiar insects, blossom later; and thus we may trace a mutual relationship between the two kingdoms throughout the sparkling spring, the leafy summer, and the melancholy autumn,—till relentless winter sets his seal upon insect life, and either renders it entirely torpid, or sheds occasionally a feeble ray on some forlorn company of gnats, whose dances, now no longer "choral," exhibit but a sad representative of that more genial season when the "living air" was filled with their not unjoyful murmurs. With these and a few other exceptions, the earliest insect season commences with the flowering of the sallow (*Salix caprea* of Linnæus, *Saugh* of the Scottish schoolboy), which is accompanied by the golden flowers of the crocus, and the beautiful green of the expanding gooseberries. "Then is your time," says Mr Kirby, "to collect many species of wild bees and *Diptera*, not afterwards to be met with; and various other insects now begin to emerge from the pupa. Another and later season is marked by the general blossoming of the butter-cup (*Ranunculus bulbosus*), accompanied by the marsh-marygold (*Caltha palustris*), and ladies' smock (*Cardamine pratensis*), when you may hunt the pastures, meadows, and marshes with success, and take some insects that do not show themselves later. The coprophagous insects are now abundant. Amongst others, *Aphodius testudinarius*, a perfectly *vernal* species, is now only to be taken, and usually flying. A *third* insect season indicated by Flora, and a very prolific one, commences with the blossoming of the hawthorn, when you must desert the meads for the inclosures. At this time all nature begins to put on her gayest attire, and all her insect tribes are now on the alert, and fill the air They are almost universally attracted by the sweet and lovely blossoms of the plant just named; so that, by examining them, you may entrap some of every order, and many that during the year will appear no more. Even many of the saprophagous insects will sip nectar from the flowers. The umbelliferous plants proclaim the fourth season of insects, particularly the wild carrot and parsnip. You will scarcely ever fail to find, if the weather is genial, *hymenopterous* and *dipterous* insects of various genera, especially such as have a *short* tongue, engaged in collecting the honey from those plants. Here you may take some of the rarer *Chrysidæ*, *Crabronidæ*, *Cercerides*, &c. and occasionally even *Coleoptera*. The last insect season may be dated from the general flowering of the thistle tribe. When these are in blossom is the best time of all to collect the humble-bees (*Bombus*), the leaf-cutter bees (*Megachile*), and many other *Apiariæ*, Lat. which alone, by their long tongues, can imbibe the honey and collect the pollen of these flowers. The male humble-bees frequent them to the last, and often seem as if they were intoxicated with their sweets."[1]

The preceding chapters contain whatever we have to say of a general nature regarding the CLASS of insects. We shall now proceed to the particular history of those primary divisions called *Orders*, the name and nature of each of which have been already briefly expounded at the commencement of this article.

ORDER I.—COLEOPTERA.[2]

Coleopterous insects have usually four wings, the two superior of which, called elytra, resemble horizontal, somewhat convex scales, which meet in a straight line along their inner margins, where they form what is called the dorsal suture. The inferior wings, which are the true organs of flight, are membranaceous, transparent, transversely folded, and covered and protected by the elytra or wing-cases. They are all masticating insects, provided with mandibles and maxillæ.

Of all the insect tribes these are the most numerous, the best known, and the most generally interesting. Their singular and varied forms, their brilliant colouring, the great size of many species, and that solid consistence which renders their collection and preservation comparatively easy, have long secured for them the devoted attention of the entomologist. Some advantages also result to their study and classification from the clearly defined and articulate forms of their external organs. The name and principal characters of the order were bestowed and defined by Aristotle, and have been adopted by almost all succeeding writers on the subject. Other characters have no doubt been added to his ancient definition of *wings in a sheath*,—such as the transverse folding of these organs, and the straightness of the suture by which the elytra are united; and several exceptions to the supposed universal attributes of the order have been discovered,—such as the female glow-worm, which has neither wings nor sheaths, and the genus *Meloe*, and many *Carabi*, which, though furnished with sheaths or elytra, are entirely destitute of true or membranaceous wings. So also, in the genera *Buprestis*, *Molorchus*, and others, we may discover exceptions to the transverse folding of the last-named organs; and the exact fitting or junction of the elytra, forming the dorsal suture, ceases to hold in the genus *Meloe*,—so that none of these characters can be regarded as universal; but as they are very generally prevalent, and a few exceptions do not invalidate a rule, it is advisable that they should be retained for the purposes of definition.

Coleopterous insects, like others, are composed of three principal portions, head, thorax, and abdomen. The *head* varies greatly both in size and form, according to the different tribes. In the great section of the *Geodephaga*, or ground-beetles, it is usually of a somewhat triangular form; in many of the short elytra'd tribes (*Brachelytra*) it is orbicular; while among the weevils (*Curculionides*) it is prolonged into a pointed rostrum or beak. The hinder part is frequently contracted into a short neck, and is inserted into a cavity of the thorax, in which it moves as in a socket. The head bears two *antennæ*, of which the form and structure differ not only in the different genera, but even in the sexes of the same species. They usually, however, consist of ten or eleven distinct articulations, the latter number being the more frequent. They are inserted in the front of the head, anterior to, and rather beneath, the region of the eyes. Their various forms, as characteristic of particular groups, will be afterwards described. The *eyes* of Coleoptera, in the perfect state, are two in number, and composite. In certain Staphylinidæ, two small yellowish points have been observed, which some naturalists have regarded as analogous to the simple or stemmatic eyes; but the sentiments of Latreille are adverse to that opinion. The actual eyes are either entire, notched, or even occasionally so completely intersected by a little corneous stalk, as to exhibit (as in the genus *Gyrinus*) the appearance of a pair on either side. The *mouth* consists of a *labrum*, two *mandibles*, two *maxillæ*, each furnished with one or two articulated *palpi*, and a

[1] *Introduc. to Ent.* vol. iv. p. 508.

[2] The derivation or etymology of the different orders has already been given in our introductory observations,—see pages 25 and 26 of this volume. Our present order corresponds to the ELEUTHERATA of Fabricius.

labium composed of two parts, the *mentum* and *ligula*, and accompanied by a pair of palpi. The mandibles are usually of a corneous consistence, but they are membranaceous and of small size, in such as take little apparent nourishment, or feed on the juices of flowers, or on excrementitial or putrescent animal fluids. The maxillæ are of a softer texture than the mandibles. When there are a pair of palpi on each maxilla, the exterior ones never consist of more than four joints; those of the labium have usually three articulations.

The *thorax* of the Coleoptera, like that of other hexapod insects, is likewise divisible into three principal portions, each of which is characterized by a particular degree of development. The *mesothorax* is very narrow, whilst the corselet or *prothorax*, and the *metathorax*, exhibit a considerable bulk. This is an important feature in the structure of the skeleton or tegument of the coleopterous order. The prothorax is always free in its movements, while the two other portions are united together, and nearly immoveable. The component parts of the mesothorax are in fact rudimentary, and those of the *scutellum* are soldered together. But the elements of the latter portion, that is, the *præscutum*, the *scutum*, the *scutellum*, commonly so called, and the *postscutellum*, still exist, and their joinings are quite perceptible in certain genera. The prothorax supports only the first pair of legs, while the mesothorax bears the second pair and the elytra. The second pair of wings and the third pair of legs are attached to the metathorax.

The elytra and wings take their origin from the lateral and superior margins of that portion of the body to which they are attached. The elytra are usually of a very firm or almost crustaceous consistence, opake, and without reticulations. The true wings are large, veined, and concealed beneath the elytra. The latter always exist (with the exception of the females of a few species), but many species are apterous, so far as concerns the existence of the membranaceous wings. In general the elytra equal the body in length, but they are sometimes, as among the Staphylinidæ, much shorter. They are usually free, and extended during the act of flight; but among several carabideous insects they seem united by the dorsal suture, and are consequently incapable of extension. In these instances the true wings are wanting.

The *abdomen* of the Coleoptera is sessile, that is, attached to the metathorax by its largest transverse diameter. Its inferior or ventral part is less extended longitudinally than the superior, and this restriction is chiefly owing to the development of the sternum of the metathorax, which is prolonged backwards, and thus, as it were, usurps the place of the abdomen. This may be very distinctly observed in the genus *Copris*, in which the segments of the abdomen seem crowded together. In some species the first segment appears divided into two parts by the sternum, which projects along their line of union. Inferiorly, the abdomen is always of a firm or horny consistence; but the upper part is generally soft, being covered by the elytra and wings. When these are wanting or abbreviated, the abdomen is equally hard above as below, as in the genus *Meloe*, and the *Staphylinidæ*, or brachelytrous tribes.

The legs vary in their structure and development. The anterior pair, or those of the prothorax, are frequently more strongly formed in the male than in the female; and in the former sex the tarsi are often broader than in the latter. The legs are usually described as composed of five pieces, the *haunch*, the *trochanter*, the *thigh*, the *tibia*, and the *tarsus*. M. Audouin has shown the existence of a sixth portion, moveable, constantly concealed within the interior of the body, and serving to articulate the haunch with the epimera. We have already mentioned it under the name of *trochantin*.

The internal structure of the Coleoptera has recently been illustrated by several ingenious observers, such as Ramdhor, Audouin, and Dufour.

The apparatus for the purposes of nutrition in coleopterous insects may be summed up as follows:[1] 1*st*, Organs of manducation; 2*d*, salivary glands; 3*d*, a digestive tube; 4*th*, biliary vessels. The entire order Coleoptera is composed of *masticating* species, which are consequently provided with instruments of a more or less resistant nature, adapted for seizing, cutting, and triturating the food previous to its being swallowed. For this purpose the mouth is furnished with a pair of corneous mandibles, sometimes simply incisive, sometimes dentated or toothed. Their motion is transverse and horizontal. There is also a pair of maxillæ, usually of a more membranaceous consistence than the mandibles, an upper lip or labrum, an under lip or labium, and from four to six palpi. The salivary glands, which in orthopterous and hemipterous insects present all the characters common to such organs, are rudimentary in size, and few in number, among the coleopterous tribes. They contain a colourless saliva, and their existence hitherto has been ascertained chiefly in genera of the families of *Melasoma*, *Taxicornes*, *Stenelytra*, *Trachelides*, *Rhincophora*, and *Aphidiphaga*. The digestive tube possesses an extent which varies singularly in relation to the habits of life of each particular tribe. In a few it scarcely exceeds the length of the body; while in others, and these are the greater number, it greatly surpasses that extent. The œsophagus is generally short; the crop more or less obvious; the gizzard is in some families garnished interiorly with triturating pieces; the chylific ventricle is of variable size, and either smooth or beset by papillæ; the small intestine likewise varies in length; the large intestine consists most frequently of a dilatable cæcum; the rectum is sometimes greatly elongated in the female sex.

The texture of the digestive tube is musculo-membranous, and is composed of three tunics of varying thickness The biliary or hepatic vessels are always inserted at the posterior extremity of the chylific ventricle. They are of great extent, extremely slender, singularly folded, and of a cellular-membranous texture. Their number and the mode of their connection vary in the different tribes and genera, but they are always of an equal number, or in pairs. There are never less than a single pair, nor more than three. Sometimes their insertion is limited to the chylific ventricle, in which case they are either free and floating by one extremity, or they form an arch variously twisted, of which the two extremities are implanted on the same circle. Sometimes the insertion is double, and obtains at one end on the chylific ventricle, and at the other on the cæcum. The bile contained in these vessels varies from a deep violet and brown colour, to yellow and white. It is sometimes even diaphanous.

The generative system among the Coleoptera is thus described by M. Dufour. "Les Coléoptères ont, ainsi que les autres insectes, deux sexes séparés, et l'acte de la reproduction est un véritable accouplement. L'organe générateur mâle se compose, 1°. de deux testicules formés, soit par les replis agglomérés d'un seul vaisseau sper-

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[1] See Dufour's *Résumé des Charactères anatomiques propres aux Coléoptères en general et aux Carabiques en particulier.* Ann. des Sciences Nat. t. viii. p. 36.

Coleoptera. matique, soit par un ou plusieurs sachets, soit enfin par des utricules dont le nombre, la configuration, et la grandeur varient suivant les familles; 2°. de deux canaux déférens variables pour leur longeur, quelquefois reployés en épidedyme; 3°. de vésicules séminales plus ou moins nombreuses, et de formes diverses suivant les genres de Coléoptères; 4°. d'un conduit éjaculateur tantôt fort long, tantôt très-court; 5°. d'une verge retractile renfermée dans une armure copulatrice dont la conformation se modifie à l'infini. On distingue dans l'organe générateur femelle de tous les Coléoptères, 6°. deux ovaires dont chacun se compose d'un calice plus ou moins marqué, et d'un nombre variable suivant les genres, de gaines ovigères uniloculaires ou multiloculaires, terminées le plus souvent par une pièce charnue où se fixe un ligament suspenseur; 7°. un glande sébacée d'une structure diversement compliquée, insérée à l'origine de l'oviducte, et destinée à furnir une humeur propre à lubrefier ou à enduire les œufs à l'époque de la ponte; 8°. un oviducte plus ou moins long qui se continue en un vagin; 9°. enfin, dans quelques cas rares un appareil sécréteur particulier propre à former une enveloppe commune ou une coque aux œufs."[1]

Besides the ordinary secreting organs, certain coleopterous species are provided with a kind of excrementary secreting apparatus, which is binary, and common to both sexes. Its function is the formation of an acrid humour, liquid or gaseous, which the insect expels as a means of defence when menaced or attacked.

The respiratory organs of the Coleoptera consist in stigmata placed along the lateral portions of the body, and of tracheæ, sometimes tubular, sometimes utricular, which disseminate the air through all parts of the system.

The nervous system is composed of a brain or upper ganglion,—of ganglia placed in the median line, variable in their number, and communicating with each other and with the brain by means of a double cord,—and of nerves, properly so called, which emanate from the ganglia.

The abdominal cavity of these insects always encloses a splanchnic adipose tissue, of which the abundance and colour vary according to the genera, and which appears to be connected with the purposes of nutrition.[2]

In addition to the usual differences, the sexes frequently present external distinctive characters in the antennæ and other parts. The male is supposed to perish soon after the sexual union, and the female does not long survive the deposition of her eggs. These eggs, which of course vary in size, form, colour, and consistence, are deposited in various localities, and among very different substances, in accordance with the instincts and economy of the species, and the habits of the larvæ about to be produced. These larvæ are also very dissimilar to each other in this varied order; but they may be generally described as soft bodied, with the exception of the head and the upper portion of the three first segments of the body, which are of a firmer or more scaly consistence. They are furnished with six feet; and the eyes, which in the perfect state are composite, are in this early condition small granuliform bodies, sometimes amounting to six on each side. The parts of the mouth bear a relation, both to their immediate mode of life, and their future development in the perfect insect. The mandibles are very strong and corneous in such species as feed on ligneous substances; they are coriaceous in such as feed on leaves, and almost membranaceous in those which prefer carcasses, or other matters in a state of putrescence. The antennæ of these larvæ are usually very short, cylindrical or conical, and composed of a small number of articulations.

Coleopterous insects enjoy a considerable length of life, Coleoptera. at least in the larva state. The period of endurance, however, of that early condition, is extremely various in the different genera of this most numerous order. Indeed, even among individuals of the same species, the continuance of the different stages of growth varies in accordance with the temperature of particular seasons, or the more or less abundant supply of food. Many species pass the winter in a listless state, abstaining almost entirely from eating, and consequently, even after the lapse of several months, present scarcely any apparent increase of their dimensions. No sooner, however, are they awakened from their temporary trance by the enlivening beams of the returning sun, than they greedily attack their favourite food, and their growth is almost instantaneous. It has been remarked that the larvæ which feed on leaves, such as those of *Crioceris*, *Altica*, and *Chrysomela*, remain but a brief period in the larva state; while the subterranean and root-devouring species, on the contrary, not unfrequently continue for two or three years in their dark abodes. Attentive observation has also ascertained that those Coleoptera which pass the winter in the egg state are the shortest lived in the form of larvæ;—they are hatched, nourished, developed, reproduce, and perish, all in the course of the summer first ensuing,—while such as pass the winter in the larva state, or that of nymph, are the longest lived in both of those conditions. It is chiefly in the form of larva that the Coleoptera produce such injury to agriculture, and other branches of rural industry. The ravages of species belonging to the genera *Bruchus*, *Curculio*, *Calandra*, *Melolontha*, *Crioceris*, *Altica*, *Anthrenus*, *Dermestes*, and numerous others, are unfortunately better known than any counteracting remedies of easy application.

The larvæ of the coleopterous tribes usually change their skins three times, and many of those which live in the earth construct a kind of cocoon, in which they undergo their transformations. These are of the kind formerly mentioned under the name of *complete* metamorphoses.

Linnæus, Geoffroy, Fabricius, Olivier, Latreille, and others, have established many divisions, more or less natural, in the coleopterous order. The number of the articulations of the tarsi varies from three to five, and their amount in each limb has been assumed as the basis of the great sectional divisions of the coleopterous order, so generally adopted by the continental naturalists. As these divisions pervade all foreign works of importance on the Coleoptera, we shall here explain their nature. Geoffroy having observed that all the species of a genus or of a family were characterized by the same number of articulations of the tarsi, and that the differences presented by these parts always bore a relation to other differences in the general organization, he conceived the idea of grounding his primary divisions on their particular structure.

Many extensive families of coleopterous insects are distinguished by *five* articulations to the tarsi; that is, by five joints on each foot. (Plate CCXXXIII. fig. 2 *e*.) All of these fall under the first general section called *Pentamera*, from πεντα, *five*, and μερος, *part* or *article*. Another extensive division is characterized by *five* articulations to the tarsi of the two anterior pair of feet, while the posterior or third pair possesses only *four* articulations. All the species so formed belong to the section *Heteromera*, so called from ἑτερος, *different*, the tarsi being dissimilar to each other. Numerous Coleoptera exhibit the tarsi composed throughout of four articulations. These

[1] *Ann. des Sciences Nat.* t. viii. p. 38.

[2] *Ibid.* p. 40.

are ranged under the general section *Tetramera*, from τετρα, *four*. Lastly, many species have no more than three, and some no more than two joints, to the tarsi, and these belong respectively to the sections *Trimera* and *Dimera*. It has even been supposed that an insect exists, the tarsi of which are furnished with only a single joint; and for its reception the section *Monomera* (from μονος, *alone*) has been established. Later and more considerate observation, however, has led to the belief that both of the last-named sections are resolvable among the trimerous species, and that the supposed absence of the second and third joints arises from their extreme minuteness.

"Nihil notatu dignius videtur," observes Mr Fischer, "constanti tarsorum insectorum imprimis coleopterorum formatione, quæ, quidquid etiam naturæ scrutatores, quidam contra eam in medium protulerint, methodum ordines insectorum in sectiones vel series minores dirimendi offert tutissimam."[1] The extreme simplicity, and consequent ease of application, of the sectional rules deduced from the structure of the tarsi, has probably induced the continental naturalists to adopt them more readily than they would have done had they foreseen the occasional contradictions to which they lead. The fact cannot be disguised that the system is in many instances artificial,—for several insects differ in the number of their tarsi, which are yet nearly allied by their general structure and attributes,—while it would be easy to show that the mere agreement in the number of those parts by no means carries along with it a corresponding relationship in the form of the other more important organs.[2] The truth is, that the articulations of the tarsi differ in some instances even in the sexes of the same species, as may be seen in *Cryptophagus fumatus* and *C. pallens;* and the consequence, as Mr Macleay has pointed out, of forming the primary divisions in accordance with their amount, has been, that many genera are separated, and thrown to a great distance from the place which nature has assigned them.[3]

While, therefore, the British naturalists have availed themselves of whatever aid these sectional divisions have legitimately afforded, they do not trammel themselves by a uniform adherence to the system, independent of its accordance with nature.[4]

We have already endeavoured, in the preceding introduction, to illustrate the geographical distribution of insects in general. We shall here add a few observations more especially applicable to the coleopterous tribes.

The coleopterous insects of Europe in general, according to M. Latreille, bear a strong affinity to those of Western Asia and Northern Africa. These traits of resemblance become more obvious, when, the qualities of the soil and the temperature being analogous, we approach towards the northern tropic. It is under the forty-fourth degree of north latitude that we begin to perceive certain species of carnivorous Coleoptera, of the Lamellicornes, of the heteromerous section, and of the Curculionides, characteristic of the warmer regions of the earth. There also may be observed species of a larger size, and of an aspect more imposing, than characterize their congeners of the north. The dominion of the *Carabi*, properly so called, so notable over all the northern and temperate countries of Europe, and in the more western regions of Asia, ceases towards the thirty-fifth degree of north latitude. These predaceous insects are succeeded by the genera *Anthia* and *Graphipterus*. Viewed in relation to entomological characters, Europe may be said to extend further eastward than it does in accordance with our actual political divisions, as the insects of the Levant, and even of Persia, exhibit a very European aspect. Austria and Hungary, from their central situation and other local circumstances, are numerically richer in species than the western countries of Europe. These latter, however, possess, in consequence probably of their littoral position, and the influence of the oceanic waters, several peculiar species, which, though unknown in the East, nevertheless extend their localities in a lengthened line from north to south. However gorgeous may be the productions of tropical regions, the European continent presents to the entomologist a rich and varied assemblage both of carnivorous and herbivorous Coleoptera. Many of these it possesses in common with other countries, while of some it has to boast a more exclusive possession. The great tribe of the Carnivora, and especially the Carabi or larger predaceous beetles—the *Staphylinidæ* or brachelytrous kinds—the *Clavicornes*—the genera *Aphodius, Meloe, Callidium, Leptura, Chrysomela*,[5] *Lixus*, &c.—are there proportionally more numerous than in any other quarter of the world. Latreille has observed that the herbivorous Coleoptera seem to prevail in South America. Many species of the northern countries of the new world greatly resemble those of the northern and temperate parts of Europe, while others are identical. Of these some may be regarded as naturally distributed alike over Scandinavia, Greenland, the adjacent islands, and North America,—while the greater proportion, which are xylophagous or timber-eating insects, have very probably been transported by artificial means, that is, in cargoes of wood, and in the timbers of our vessels. Notwithstanding many examples which might be adduced to illustrate a certain agreement which exists between the species of Europe and North America, the more general as well as precise truth is, that the entomology of North America is connected by a stronger affinity with that of the southern division of the new world than with that of our own continent and islands. We cannot, for instance, exhibit a single example of that division of *Cetonia* of which the thorax presents a posterior lobe, nor of *Galerita, Tetraonyx*, or *Parandra*, genera which are distributed throughout the whole of America. One strong feature of conformity has indeed been observed, that North America and Europe both possess many carnivorous Coleoptera entirely unknown in the equatorial regions either of the old world or the new.[6]

The coleopterous order is extremely numerous in species. Comte Dejean's collection, probably the most extensive hitherto made, is said to contain above twenty

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[1] *Genera Insectorum*, Præf. p. 5.

[2] "Ce n'est pas assez," says Clairville, "pour pallier les frequentes anomalies qui se rencontrent, de dire que tel insecte a cinq articles aux tarses quoiqu'on n'en découvre que quatre. Il devroit en effet en avoir cinq d'après la règle qu'on a établie. Cependant ces explications, toutes ingenieuses qu'elles sont, ne peuvent me convaincre, et je ne puis me détérminer a supposé plus d'articles aux tarses qu'on ne peut réellement en decouvrir, en y mettant toute l'attention possible. Le nombre des articles doit être clair, positif, et uniforme, sans quoi le charactère est vacillant. Au reste, je ne disconviendrai pas que sans être rigoureusement propres à diviser les ordres, ils ne puissent tres-bien servir pour un tableau dans lequel les genres seroient ordonnés selon le nombre des articles des tarses." (*Entomologie Helvétique*, p. 30.)

[3] *Horæ Entomologicæ*, part i. p. 6.

[4] *Entomologia Edinensis*, Introduc. p. 23.

[5] M. Lacordaire, however, has recently shown that the *Chrysomelidæ* are very numerous in the tropical regions of South America. See *Nouvelles Annales des Mus.* t. ii. p. 94.

[6] *Introduction à la Géographie générale des Arachnides et des Insectes, ou des climats propres à ces Animaux.* Par Latreille.

thousand different kinds; and Mr Stephens' *Nomenclature of British Insects* (second edition) presents us with the names of 3614 indigenous Coleoptera.

In relation to the economical uses of the order, we may observe that coleopterous insects are scarcely if at all applied in the arts. Those employed in medicine are chiefly the *Cantharis vesicatoria,* commonly called the Spanish Fly, and the *Mylabris Cichorii,* which in China and the Levant is likewise used as a blistering application. The Romans are supposed to have made use of certain coleopterous larvæ for dietetical purposes; and some of the South American tribes are known to devour with delight the fattened larvæ of the *Curculio palmarum.* We shall conclude these introductory observations by a few remarks

On the collecting and preserving of Coleopterous Insects.

This is a very simple matter to those who are zealous in the cause. By far the best method is for the collector to provide himself with a few stout phials half filled with whisky, or any other ardent spirit which he may happen to prefer. When the insects are caught, which they can only be in any considerable number or variety by a sedulous search under stones, and in the other localities afterwards indicated in our notices of the different genera, they may be popped into the phial, where in most instances they die almost instantaneously. This is not only the most humane process, but it is also the best mode of preserving their more delicate portions uninjured. It likewise puts an end to all contention among themselves, which is by no means the effect of the ordinary method of collecting in small boxes,—for in the latter case the larger and more voracious invariably devour the smaller or least assuming; and thus many captures, regarded with pleasure in the morning, are found to have disappeared in the afternoon. If time and opportunity are wanting for the immediate purpose of *setting* the specimens, that is, placing them in their most appropriate positions, they may be allowed to remain in the phials for days or weeks without being injured, although in that case greater care is afterwards necessary, especially with the smaller specimens, in consequence of a certain softness in the articulations, induced by maceration in the spirits. When an entomologist (in search of Coleoptera) is employed in what we may call the *home circuit,* he requires during his excursions nothing more than a couple of glass phials, as we must suppose him possessed of all other appliances within his dwelling. But during a more distant and prolonged journey, he must provide himself with a few small boxes made either of wood or tin (the last is lighter and thinner, and therefore more commodious), lined with cork at top and bottom, and deep enough to contain an upper and an under range of pins. In these the insects caught during the day may be transfixed in the course of the evening, so that the phials may be left empty for the captures of the ensuing morn. Notes ought to be taken of the places of capture, and the insects should be so arranged in the boxes that, by means of numerals or other marks, any individual may be afterwards recognised in relation to its own particular locality.

The *setting* of an insect consists merely in placing its limbs and antennæ in a natural position, and fixing them in the same for a time by means of pins, on a small board on which there is a layer of cork. (Plate CCXXXIII. figs. 10 and 12.) They stiffen in a few days, and may then be transferred to their proper places in the cabinet. If not set when either moist or recent, they may be softened by being placed for a night in any small vessel containing a layer of wet sand, and covered with a damp cloth to prevent evaporation. The same process, continued for a somewhat longer time, is equally efficient in regard to foreign species. Each specimen, if not stuck, should, previous to setting, be transfixed by passing a pin through the elytra and abdomen, at right angles with the plane of its position,—enough of the pin being made to project beyond the feet as will suffice to fix its point firmly in the cork.

When mould appears upon coleopterous specimens, they ought to be exposed for some hours at the distance of two or three feet from a brisk fire, and then delicately brushed with a hair pencil. When mites or acari make their appearance among them, they ought either to be exposed for a few minutes to a high temperature, which kills the living parasites without injuring the dead insects, or each specimen ought to be carefully washed by means of a hair pencil dipped in spirit of turpentine. A piece of sponge constantly saturated with that fluid, or a supply of camphor, should be kept in each drawer. With a view to maintain a collection in good order, it is very advisable that all specimens obtained from correspondents by purchase or exchange should, previous to their being placed in the cabinet, be submitted to the ordeal of a bath either in spirit of turpentine or camphorated spirit of wine. If mites or acari are once introduced into a cabinet of considerable extent, their eradication is extremely troublesome. As many collectors are careless of their duplicate specimens, and as it is of course with these that they supply their friends, much injury is frequently inflicted by the introduction even of a single insect in bad condition into a cabinet previously in a proper state.[1] We must now proceed to a more detailed exposition of the coleopterous tribes. They are grouped together under four great sections, according to the number of joints in the tarsi.

PENTAMERA.

All the Tarsi composed of Five Joints.[2]

FAMILY I.—CARNIVORA, Cuv. ADEPHAGA,[3] Clairv.

The first primary division of the coleopterous order contains a numerous and varied assemblage, all of which, however, agree in being, as the name imports, of a voracious disposition. Each maxilla is furnished with two palpi, so that there are *six* in all, including those of the labium.

In the larva state, these insects are elongated, cylindrical, composed of twelve rings or segments, exclusive of the head, which is large, of a scaly texture, and provided with two strong mandibles curved at their extremities. The mouth is also furnished with a pair of maxillæ divided into two branches, one of which is formed by a palpus. The ligula bears two palpi, which are shorter than those of the maxillæ. The head is moreover provided with a pair of short conical antennæ, and six small simple

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[1] *Entomologia Edinensis,* Introduction, p. 57.

[2] We have already stated our opinion of the artificial combinations which occasionally result from the use of this principle of sectional division, and in our *Entomologia Edinensis* we have, with our coadjutor, the Rev. James Duncan, followed another mode of arrangement. But in presenting a general view of the subject, and one in which numerous foreign genera are included, we think that greater clearness will result from an adherence to the system of the continental entomologists. We therefore now follow M. Latreille.

[3] So named from *αδηφαγος,* voracious.

eyes on each side.[1] The first segment of the body is covered by a squamous shield,—the others are soft. The first three segments are each furnished with a pair of legs, of which the extremity is curved forwards.

Of course many modifications occur in the form and aspect of adephagous larvæ. For example, those of the Cicindelæ have the upper portion of the head hollowed out in the centre, while the inferior portion is bulged. Two of the eyes on each side are much larger than the others, and the shield of the first segment of the body is also large, and of a semicircular shape. The eighth segment bears two small hooked processes in its upper surface. Among the generality, however, of these larvæ, the head is weaker and more regular, and the eyes are of equal size. The shield is square, and does not project over the sides; the eighth segment wants the processes; but the terminal segment is furnished with two conical appendages, besides a membranous tube formed by the prolongation of the anal portion of the body. These appendages are toothed and horny in the larvæ of *Calasoma* and *Carabus*. In *Harpalus* and *Licinus* they are more elongated, fleshy, and articulated. In these and other genera, the form of the mandibles in the larvæ approaches that of the same species in the perfect state.

The adephagous Coleoptera have always a first stomach, which is short and fleshy,—a second, which is more elongated, and shaggy on the surface, by reason of the numerous small vessels with which it is furnished,—and a short and slender intestine. The hepatic vessels, four in number, are inserted near the pylorus. These insects may be regarded as terrestrial (*Geodephaga*) and aquatic (*Hygrodephaga*), according to their mode of life.

The genera of the former subdivision of the order dwell and take their food upon the surface of the earth. They are hence known under the name of ground-beetles. The feet of these *terrestrial* species are formed for tolerably rapid motion, and the two posterior pair are inserted at equal distances. The mandibles are obvious and discovered, the terminal portion of the maxillæ is straight inferiorly, and curved only at its extremity. The body is generally oblong,—the eyes projecting. The tracheæ are tubular or elastic, and the intestine is terminated by an expanded cloaca, provided with two small sacs which produce an acrid humour.[2]

Tribe 1st, Cicindeletæ, Lat.

This tribe corresponds to the genus Cicindela of Linnæus. Its genera are distinguished by a hook or nail, which is articulated by its base to the tip of the maxillæ. All the species have a strong head, with large eyes, projecting toothed mandibles, and a short ligula concealed behind the mentum. The labial palpi are composed of four distinct articulations, and, in common with the maxillary palpi, are generally shaggy, or somewhat clothed. The precedence is usually assigned to these insects in our systematic arrangements, from motives probably similar to those which have induced ornithologists to place the accipitrine order at the head of the class of birds. The greater proportion of the species are exotic.

Genus Manticora,[3] Fab. Tarsi alike in both sexes, and composed of cylindrical articulations. Mandibles large and arched. Head very large. Eyes small, and not greatly projecting. Back of the thorax forming a kind of semicircular lobe, prolonged as far as the posterior margin. Abdomen pediculated, almost entirely enveloped by the elytra, which are nearly heart-shaped, soldered, and laterally carinated.

M. *maxillosa*, Fab. (Pl. CCXXXIV. fig. 1.) Entirely black, and covered with scattered hairs. The mandibles have four interior teeth, of which the third is the least. The antennæ are slender and filiform, their third articulation angular and elongated. The thorax appears as if divided into two by a transverse groove near the anterior margin, which is prolonged laterally, and beneath, as far as the origin of the fore-legs. There is no scutellum visible. The legs are large, and covered with stiff hairs.

This formidable-looking insect, which measures more than an inch and a half in length, presents the aspect of a large spider. It inhabits sandy soil in the southern parts of Africa, and is the only known species of the genus, unless the *M. pallida* of Fab. referred by Mr Macleay to his genus *Platychiles*,[4] is still to be regarded as a Manticora.

Genus Megacephala,[5] Lat. The first three joints of the anterior tarsi of the males dilated, short, almost in the form of a reversed triangle, more strongly ciliated inwards than externally. Labial palpi longer than the maxillary,—their first articulation elongated, projecting beyond the mentum, the second very short, the third very long and cylindrical, the last securiform. Labrum short and transversal, leaving the mandibles exposed.

This genus was constituted by Latreille by the removal of certain species of *Cicindelæ* of Fabricius. It occurs both in Africa and America. Those from the former country are apterous, from the latter winged. We know little more of their habits than that they are extremely active. We are acquainted with fifteen species, none of which occur in Europe.

M. *megalocephala*, Lat. Of a bronzed black colour; the mouth, antennæ, and feet pale yellow. Elytra with rows of hollow spots. From Senegal.

In the genus *Oxycheila* of Dejean (*Species Gén.* t. i. p. 15) the labrum is very large, with a projecting point, and covers the mandibles. It is formed from the *Cicindela tristis* of Fab., and is named from ὀξὺς, *pointed*, and χεῖλος, *lip*.

Genus Cicindela, Lin. (Pl. CCXXXIV. figs. 2, 5.) The first three joints of the anterior tarsi of the males dilated, elongated, nearly cylindrical, and more strongly ciliated inwards than externally. Labial palpi not surpassing the length of the maxillary; their first two joints very short, the first not passing beyond the extremity of the mentum, the third cylindrical, the last slightly enlarged at its extremity.

The name by which our present genus is distinguished is used by Pliny as synonymous with *Lampyris*, to designate a kind of luminous insect, a frequenter of corn fields.[6] It likewise appears to have been applied by ancient writers to various destructive insects which it would now be difficult to identify, although they are no doubt known to naturalists. In modern times it was originally bestowed by M. Geoffroy on the species at present classed under the genera *Malachius* and *Telephorus*, and was afterwards transferred by Linnæus to the insects above defined, as well as to other species not now included in *Cicindela*.

Their larvæ inhabit holes in the earth, the entrance to which, while the occupant lies in ambuscade, is closed by the upper portion of its head. They are exceedingly

[1] So says Latreille. Some authors state the number of these eyes as only three on each side.

[2] *Règne Animal*, tom. iv. p. 358. An abstract of the anatomical characters of the insects of this division, by M. Dufour, will be found in the *Annales des Sciences Nat.* tom. viii. p. 36.

[3] Μαντιχωρα is the name of a fabulous animal mentioned by Aristotle, Ælian, and Pliny.

[4] *Annulosa Javanica*, vol. i. p. 9.

[5] From μεγας, *great*, and κεφαλη, *head*.

[6] Plin. viii. c. 26.

Coleoptera Pentamera.

voracious, and seize with their maxillæ whatever insect prey approaches within their tyrannous grasp. The bodies of these larvæ are long, cylindrical, whitish, and furnished with six scaly feet. When approached by human footsteps, or otherwise threatened by danger, they rapidly descend into their subterranean retreats. When two of these larvæ happen to form their domiciles in the immediate neighbourhood of each other, the stronger devours the weaker, with a view to obviate any interference with his own pursuits. They seal up the entrance to their dwellings when about to change their skins or assume the state of nymph.

The perfect insects are extremely beautiful, of light and active forms, exceedingly swift in their motions, and adorned by brilliant metallic colours. The prevailing hues are different shades of golden green, spotted with white or pale yellow. They frequent dry and sandy soils, where they seem to enjoy the prevalence of bright sunshine. The species are extensively distributed over all the regions of the earth. Their organs of locomotion, and those more immediately subservient to the preservation and nutrition of the individual, are very fully developed, and present in the most perfect form all the attributes which distinguish the entomophagous or insect-eating Coleoptera. They were named by Linnæus the tigers of the insect tribes. "Though decorated with brilliant colours, they prey upon the whole insect race; their formidable jaws, which cross each other, are armed with fearful fangs, showing to what use they are applicable; and the extreme velocity with which they can either run or fly renders hopeless any attempt to elude their pursuit. Their larvæ are also equally tremendous with the imago, having six eyes, three on each side, seated on a lateral elevation of the head, which look like those of spiders; and, besides their threatening jaws, armed with a strong internal tooth, being furnished with a pair of spines resembling somewhat the sting of a scorpion, which stand erect upon the back of the abdomen, and give them a most ferocious aspect."[1] It is this last apparatus which, according to Clairville, serves the purpose of an anchor in retaining these larvæ at any desired height in their sandy cells.

Dejean's catalogue (2d edition) contains 201 species of the genus Cicindela as now restricted.

C. *campestris.* Green, with five whitish spots on the margin of each elytron, and another in the centre. The spots on the elytra vary in shape and disposition, and some of them are occasionally obliterated. The female has two fuscous spots towards the base of the elytra, and is distinguished, in addition to the more slender tarsi, by having the abdomen divided into six segments; that of the opposite sex consisting of seven, with the penultimate one more or less emarginate. This sexual distinction, first observed by Gyllenhal, exists in most genera of the tribe.

This beautiful insect frequents dry sandy places exposed to the sun, most commonly in the neighbourhood of heaths, and is distributed more or less abundantly over all parts of Britain. We have traced it through most of the Highlands of Scotland, as far as the south of Sutherland, and we doubt not that it extends to the most northern extremity of the island. It is an inhabitant of most European countries, ranging from the shores of the Mediterranean to Siberia. This is the most abundant of the British species, and the only one yet found in Scotland. The supposed species *C. Maroccana*, Fab. which occurs in Spain and along the coast of Barbary, is now regarded as one of its varieties.

Besides the preceding, five or six other species are described as British. *C. germanica*, an English insect, common in France and Germany, differs in its habits from the rest of the genus. When we attempt to seize it, it does not fly off like the others (although it is winged), but endeavours to escape by running rapidly among the herbage by which it may be surrounded.

The genus *Euprosopus* of Latreille and Dejean, of which the tarsi are equally ciliated on both sides, was established on *Cicindela quadrinotata* of Fab. The species are said to dwell on trees. In the genus *Therates*, Lat. the tarsi are nearly alike in both sexes. The internal maxillary palpi are very small, indistinct, and apparently uniarticulate. The species are confined to the eastern parts of Asia, such as Java, the isles of Sunda, and those to the north of New Holland. *C. labiata* of Fab. belongs to the genus last named, which is synonymous with *Eurychiles* of Bonelli.[2] *C. Aptera* of Olivier forms the genus *Tricondyla* of Latreille.

Genus Colliuris, Lat. Fourth articulation of all the tarsi prolonged obliquely inwards in both sexes. Body narrow and elongated. Thorax almost cylindrical, narrowed anteriorly. Antennæ short, thickening more or less towards the extremity. Last article of the labial palpi dilated.

The title of *Colliuris* was bestowed originally by Degeer, upon an insect belonging to the genus *Casnonia* of Lat. It was established according to its present character by Fabricius under the name of *Collyris*, which has been altered as above by the majority of authors. These insects appear to be all provided with wings. All the species yet met with have been found in the most southern countries of Asia, and in the islands lying north of New Holland.

C. *longicollis*, Dej. Blue, sometimes tinged with violet. Thighs and hind tarsi ferruginous red. Elytra deeply punctured. This species was taken in Java by the excellent Westermann of Copenhagen, who presented it to Comte Dejean as the true *C. longicollis* of Lat. The insect so named by Latreille (*Gen. Crust. et Insect.* i. p. 174) is the *C. emarginata* of the *Species Général*, t. i. p. 165.

We shall conclude our sketch of this tribe by presenting a *synoptical view* of its most recent constitution, according to the system of Dejean.

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[1] *Introd. to Entomology*, vol. ii. p. 263.

[2] *Mem. della R. Acad. di Torino*, xxiii. part 1st, p. 248.

Coleoptera Pentamera.

CICINDELETÆ.

- Mentum with a tooth in the centre of its notch. The three first joints of the anterior tarsi
  - not dilated in the males........ 1. *Manticora.*
  - dilated in the males. Third joint of the anterior tarsi of the males
    - not elongate. Penultimate joint of the labial palpi
      - not inflated. Labial palpi
        - elongate, at least as long as the maxillary pair, the last joint securiform. Upper lip
          - transverse or slightly notched. First joint of the labial palpi
            - not extending beyond the notch of the mentum.... 2. *Platychile.*
            - extending beyond the notch of the mentum........ 3. *Megacephala.*
          - covering the mandibles,
            - triangular........ 4. *Oxycheila.*
            - semi-oval........ 5. *Iresia.*
        - slightly elongate, not exceeding the maxillary pair; last joint not securiform........ 6. *Cicindela.*
      - inflated and larger than the last. The three first joints of the anterior tarsi of the males
        - elongate and nearly cylindrical........ 7. *Dromica.*
        - somewhat elongate and flat........ 8. *Euprosopus.*
    - produced obliquely on the inner side........ 9. *Ctenostoma.*
- Mentum without a tooth in the centre of its notch.
  - Third and fourth joints of the tarsi much shorter than the first........ 10. *Therates.*
  - Joints of the tarsi nearly equal.
    - Three first joints of the anterior tarsi of the males dilated; the third produced obliquely on the inner side........ 11. *Tricondyla.*
    - Fourth joint of all the tarsi produced obliquely on the inner side in both sexes........ 12. *Colliuris.*

TRIBE 2D, CARABICI, Lat.

This important tribe corresponds to the old and unrestricted genus *Carabus* of Linnæus. The maxillæ are terminated simply by a point or hook, which is not articulated, as in the preceding genera. The head does not exceed the breadth of the thorax, and is more frequently somewhat narrower. The mandibles, with few exceptions, are but sparingly toothed. The ligula is usually projecting, and the labial palpi exhibit only three free articulations.[1] Many species are apterous, that is, have no membranous wings beneath the elytra. Their odour is often fetid, and their bodies exude an acrid fluid. The habits and economy both of the larvæ and perfect insects are exceedingly various. Some conceal themselves under the earth, others beneath stones, or the bark of trees. They are active in their movements, and are very generally distributed, being, however, more characteristic of temperate than equatorial regions. M. Geoffroy bestowed the generic name of *Buprestis* upon carabideous insects, on account of the injury which he supposed them capable of inflicting on cattle; and it is possible that the caustic humour with which many of them are imbued might be productive of bad effects in the event of their being swallowed along with better and more accustomed pasture. To whatever species this evil tendency was attributed, the ancients appear to have regarded its other characters with admiration, for the physicians of olden times held it as equal in virtue to Cantharides. Linnæus, however, transferred the name of Buprestis to the genus *Cucujus* of Geoffroy, although none of the latter genus in any way corresponded to the Βουπρηστις of the Greeks. The change proposed by the great reformer has been universally adopted, and the word Carabus is now most familiar to the ear of the entomologist.

As the larvæ of the Carabici dwell in subterranean retreats, a knowledge of their habits and history is difficult to acquire. The body is of an elongated form; the legs are six in number, and of a scaly texture; and the maxillæ are strong and pincer-like. With these they seize upon the larvæ of other insects, which constitute their favourite food. They are extremely voracious.

In relation to the economical purposes of the human race, the tribes now under consideration are of no great utility. It is mentioned, however, by the younger Geoffroy, that while he was collecting insects on the coast of Senegal, a negro brought him a jar containing many thousand specimens of a small carabideous species, which had evidently been previously collected by design. On inquiry he found that they were used for making *soap*, some of which, of a black colour, he afterwards examined, and found it to possess all the qualities of the European article. Olivier asks whether we could not extract from our indigenous species an alkaline matter subservient to the same ends?[2]

[1] In the genus Cicindela the radical joint is free, on which account the palpi are said to consist of four articulations; but among the Carabici it is adherent, and, forming only a support to the others, is not itself regarded as an articulation.

[2] *Hist. des Insectes*, vol. iii. No. 35, p. 11.

A.

Exterior palpi not subulate or awl-shaped at their extremity; the last articulation not united with the preceding so as to form an oval body with a sharp point, or a conical one with a slender and acicular termination.

*

Two anterior tibiæ with a deep emargination in the internal side separating the two spines, which are usually placed near each other, at the extremity of that side.

Section 1st, Truncatipennes.

This group derives its name from the aspect of the elytra, which appear as if cut at their extremity, or more or less truncated. This is the prevailing character, although *Odocantha dorsalis* and Dejean's new genus *Stenodactyla* present a rounded termination; but in seeking a natural system, it is the totality of organization or assemblage of characters by which we must be guided, and not by a single feature, although by its wide prevalence that feature may have been assumed, as in the present instance, for a general basis in the naming of the entire group. The two following genera present rather a sinuation than a truncation of the extremities of the elytra.

Genus Anthia,[1] Weber, Fab. Terminal joint of the palpi almost cylindrical, or slightly enlarged at the extremity. Antennæ filiform. Labrum rounded, advanced, and almost entirely covering the mandibles. No tooth in the centre of the emargination of the mentum. Anterior tarsi slightly dilated in the males. Body thick, more or less elongated. Thorax more or less heart-shaped. Elytra convex, not much truncated, or nearly round at their extremity.

The insects of this genus are of considerable size. Their usual colours are black spotted with white. They inhabit the African deserts, and are not altogether unknown in those parts of Asia which extend from the Red Sea to Bengal. According to Leschenhault de Latour, they emit a caustic fluid when handled. In the males of some species the thorax is dilated and bilobed posteriorly. Both sexes are destitute of wings. Dejean's Catalogue contains seventeen species, all of which, except one, are African.

A. *maxillosa*, Lat. Black and smooth. Mandibles very long. Thorax bilobed posteriorly. This is a large insect from the Cape of Good Hope. It measures nearly two inches in length.

A. *decemguttata*, Dej. (Pl. CCXXXIV. fig. 8.) Usually black above, the eyes brownish, a small white spot on each side of the anterior portion of the thorax. The elytra have each four deep grooves, with another in the centre common to both. These grooves are garnished with an ash-coloured or brownish down, which sometimes entirely disappears, and then each groove exhibits two rows of small excavated spots, with a longitudinal and slightly elevated line in the centre. Each elytron has also five spots formed of whitish down,—the first near the base of the exterior margin; the second a little in advance of the middle, in the second groove; the third and fourth rather behind the middle, and on the same line, in the first and third grooves; the fifth near the exterior margin, at the extremity between the second and third grooves. The under parts of the body and feet are of a more shining black. The thighs are sometimes reddish brown.

This species is extremely common at the Cape of Good Hope. It is subject to great variation in its markings, and has been described under various names in its different conditions. According to Dejean, the *Anthia quadriguttata*, Fab. which we have figured in this work (Plate CCXXXIV. fig. 3), is nothing more than a variety of the above, with three of the spots effaced from each elytron.

Genus Graphipterus,[2] Lat. Last article of the palpi cylindrical. Antennæ filiform, much shorter than the body. Labrum projecting, rounded, and nearly covering the mandibles. No tooth in the centre of the emargination of the mentum. Anterior tarsi not sensibly dilated in the males. Body large and flattened. Thorax heart-shaped. Elytra plane, broad, of a slightly elongated oval, more or less suborbicular.

We owe to Latreille the dismemberment of these insects from the *Anthiæ*, with which they were combined by Fabricius. However, they are equally apterous, inhabit the same parts of the world, and exhibit analogous colours. Although several insects of the north of Africa have been discovered in Italy and the south of Spain, the warmer countries of Europe have as yet been sought in vain for any species of either of the genera just named.

G. multiguttatus, Dej. (Pl. CCXXXIV. fig. 7.) Dull black above, of a brighter black below. Thorax margined with white. The elytra with a sinuous margin of white, and eight spots on each of the same colour.

This species was brought by Olivier from Egypt, and given to his friends and correspondents under the above name, although it certainly does not agree with the description of the insect so named by the author in his *Entomologie* and the *Encyclopédie Méthodique*.

Genus Aptinus, Bonelli. Terminal article of the palpi rather larger than the preceding, and slightly enlarged towards the extremity. Antennæ filiform. Labrum short, and leaving the mandibles exposed. No tooth, or a very small one in the centre of the emargination of the mentum. The first three articles of the anterior tarsi sensibly dilated in the males. Thorax heart-shaped. Elytra oval, increasing in breadth towards their extremity.

This genus greatly resembles *Brachinus*, with which it was combined by Fabricius, and with which it is still frequently confounded.[3] All the species belong to Africa (chiefly the Cape district) and the southern parts of Europe. Like the Brachini, they occur in groups under stones, and affect mountainous situations. They are similarly characterized by their power of emitting a penetrating vapour. The larger species inhabit tropical climates. The *A. balista*, Dej. measures from five to eight lines in length. It is black, with a fulvous throat and truncated elytra. It occurs in Navarre, and various parts of Spain and Portugal. A smaller species, of a deep black, with sulcated elytra, the antennæ and palpi fulvous, the feet russet yellow, was discovered by Dejean among the eastern Pyrenees. It is extremely common under stones on the mountains in the vicinity of Pratz de Mollo, and is named *A. pyrenæus*.

Genus Brachinus,[4] Weber, Fab. This genus scarcely differs from the preceding. It is, however, characterized by the possession of wings, the anterior tarsi are not usually dilated in the males, the truncation of the elytra is rather square than oblique, and these parts are usually more parallel, or less enlarged at their extremities, than among the Aptini.

[1] The name Ανθιας is bestowed by Aristotle on a fish.

[2] The name probably refers to what may be construed into an occasional resemblance of written characters upon the wings,—γραφω and πτερον.

[3] All the foreign species of the above genus in the Comte Dejean's printed *Catalogue* (1st edition) are *Brachini*.

[4] Probably from Βραχυνω, *I shorten*, in allusion to the truncated form of the elytra.

The Brachini, as far as yet known, have no representative in Scotland. But as the southern parts of the kingdom produce five species, we are not without hope that some of these may ere long be discovered on the northern side of the Tweed. It is, however, evidently a southern genus, for of the nineteen species of the first division of Dejean, only one, the *B. Hispanus* of Kollar, is found in Europe. It was taken at the southern extremity of Spain, by an Austrian naturalist, who happened to disembark in the bay of Algesiras in the course of his voyage to Brazil. Of the twenty-one species which constitute the second division of the genus, eight occur in Europe; and of these five are English.[1] The character by which the generality of these insects are so remarkably distinguished is, that the abdomen contains peculiar organs which secrete a caustic liquor of an extremely penetrating odour. When this is propelled by the insect on any threatened danger, it produces a detonating sound, and evaporates. M. Dumeril has remarked, that when this reservoir is opened by dissection, the liquid effervesces, and evaporates instantaneously. Paper imbued with a blue vegetable dye is changed by its action, first into a eddish hue, and then into yellow. When the vesicle which contains it is placed upon the tongue, and compressed, a peculiar and rather agreeable savour is felt in the mouth. A sharp pain, however, soon follows on the spot affected, where a yellow colour becomes perceptible, similar to that produced by a drop of nitric acid. Leon Dufour has made us acquainted with the apparatus employed in the production of this fluid.[2]

It is stated by Rowlander that the Brachini are capable of producing eighteen or twenty discharges at a time. Mr Stephens has invariably found them ready to discharge their ammunition at all times, especially when roughly handled; and Mr Cooper informed him that a specimen he met with at Cobham in the spring, performed the operation no less than thirteen times in rapid succession.[3]

B. *Jurinei*, Dej. (Pl. CCXXXIV. fig. 6.) Testaceous. The elytra black, grooved, with the lateral margins and a central spot testaceous. From Senegal.

Genus Casnonia, Lat. Terminal article of the palpi of an oval form, almost pointed at the end. Antennæ much shorter than the body, their articulations of nearly equal length,—the first being shorter than the head. Tarsi filiform; the last article at most bifid. Thorax in the form of an elongated neck, cylindrical, and very narrow anteriorly. Head nearly lozenge-shaped, prolonged and narrowed posteriorly.

The Casnoniæ are insects of singular forms, reminding he observer of the aspect of *Raphidia* and *Apoderus*. They composed the original genus *Colliuris* of Degeer; Linnæus placed them among his *Attelabi*, while Fabricius and Herbst ranged them in the genus *Odocantha*. Latreille formed the genus in which we now place them. It is synonymous with *Ophionea* of Klug.[4] Most of the species come from America. *C. cyanocephala* occurs in Bengal.

Genus Odocantha, Fab. Characters nearly the same as the preceding. Thorax elongate oval, nearly cylindrical. Head oval, narrowed behind, but not posteriorly prolonged.

O. *melanura*, Fab. Greenish blue, the base of the antennæ, chest, and feet testaceous. The elytra testaceous, with a spot of blackish blue at the extremities. The ends of the thighs black.

Dejean retains only two species in this genus, as above defined, viz. the one just described, which is the sole British species, and *O. Dorsalis*. The former insect occurs in the temperate and colder countries of Europe, in moist and marshy places; the latter is from North America.

We pass over the genus *Zuphium*, of which one species, *Z. olens*, is remarkable for occurring in France, Spain, Italy, the southern provinces of Russia, and the East Indies,—the genus *Polistichus*, of which *P. fasciolatus* is found in Britain,—the genus *Helluo* of Bonelli, of which all the species are foreign to Europe,—the genus Drypta, which has representatives in Africa, New Holland, and the East Indies, and of which *D. emarginata* is British (for a representation of *D. ruficollis*, see Pl. CCXXXIV. fig. 9),—the genera *Galerita*, *Ctenodactyla*, *Agra*, *Cymindis*, Lat. (*Tarus*, Clairville, of which *T. basalis*, Gyll. occurs in the south of Scotland), and *Calleida*.

Genus Demetrias, Bon. Hooks of the tarsi dentated beneath. Terminal article of the palpi cylindrical. The first three articles of the tarsi almost triangular, the last strongly bilobed. Body elongated. Head oval, slightly narrowed posteriorly.

These little insects, as far as we know, are all European. They are frequent in spring, on briars and hedges. We have four British species, one of which, *D. obscurus*, we owe to the recent researches of Mr Newman.

Genus Dromius,[5] Bon. Resembles the preceding; but the articles of the tarsi are entire, and nearly cylindrical. The species are apterous.

The Dromii formed part of the genus *Lebia* of Latreille, till their separation by Bonelli. They are almost all European, and are commonly found under stones, and beneath the bark of trees. Britain produces about twenty species.

Genus Lebia. Hooks of the tarsi dentated beneath. Terminal article of the palpi nearly cylindrical and oval, and truncated at the end, but never securiform. Antennæ filiform. Articles of the tarsi nearly triangular or heart-shaped, the penultimate bifid or bilobed. Body short and flat. Thorax short, transversal, broader than the head, prolonged posteriorly in the middle. Elytra broad, and nearly square.

This genus, which is comparatively numerous in European species, and is likewise known in America, and more sparingly in Africa, has been divided by Bonelli into two. The type of the first division (genus *Lamprias*) is *Leb. chlorocephala*, a beautiful little insect, of a brilliant bluish green, with the base of the antennæ, legs, breast, and thorax red, the tarsi black. It occurs occasionally near Edinburgh, and has been taken as far north as Lairig, in Sutherland. The type of *Lebia* proper is *L. crux minor*, and this second division is characterized by the penultimate joint of the tarsi being bilobed, while in the first it is said to be simple. However, as far as we are able to perceive from an inspection of our north-country specimens, there is a bilobation in that part also in *Lamprias*. But other distinctive characters will be found detailed in the works of Messrs Curtis and Stephens, both of whom follow Bonelli in regarding the two divisions as distinct genera. Dejean's *Catalogue* contains sixty-four species.

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[1] The *Catalogue des Col.* 2d ed. contains seventy-seven in all.

[2] Mém. sur le Brachine Tirailleur, *Ann. du Mus.* t. xvii. p. 70, and *Ann. des Sciences Nat.* t. vi. p. 320.

[3] Stephens' *Illustrations*, vol. i. p. 35.

[4] *Entomologiæ Brazilianæ Specimen.*

[5] From δρομιος, *a runner.*

Coleoptera Pentamera.

Synoptical Table of the preceding Section, according to the system of Dejean.

TRUNCATIPENNES.

First Sub-Tribe.

- Last joint of the palpi usually ovate, and terminating nearly in a point. Claws
  - without teeth. Joints of the tarsi
    - nearly cylindrical, or very slightly triangular. The penultimate
      - not bilobed. Thorax
        - in the form of a lengthened neck, often cylindrical and contracted in front .... 1. *Casnonia.*
        - more or less ovate or rounded. Antennæ
          - covered with hairs .... 2. *Lasiocera.*
          - simple .... 3. *Odacantha.*
      - strongly bilobed .... 4. *Leptotrachelus.*
    - broad, flat, and triangular or heart-shaped. First joint of the antennæ
      - much shorter than the head .... 5. *Trigonodactyla.*
      - nearly as long as the head .... 6. *Cordistes.*
  - with teeth beneath .... 7. *Ctenodactyla.*
- Last joint of the maxillary palpi more or less securiform. Claws
  - without teeth. Penultimate joint of the tarsi
    - strongly bilobed .... 8. *Drypta.*
    - not bilobed. The three first joints of the anterior tarsi of the males
      - very much dilated .... 9. *Galerita.*
      - scarcely or not at all dilated. Last joint of the labial palpi
        - more or less securiform. First joint of the antennæ
          - as long as the head .... 10. *Zuphium.*
          - shorter than the head .... 11. *Polistichus.*
        - nearly cylindrical .... 12. *Diaphorus.*
  - with teeth beneath .... 13. *Agra.*

Coleoptera Pentamera.

SECOND SUB-TRIBE.

- Claws with teeth beneath. Body
  - more or less elongate. Last joint of the labial palpi
    - strongly securiform, at least in the males. Penultimate joint of the tarsi
      - not bilobed .... 14. *Cymindis.*
      - bilobed .... 15. *Calleida.*
    - not securiform. Claws
      - with very large teeth .... 16. *Onypterygia.*
      - with small teeth. Penultimate joint of the tarsi
        - bilobed .... 17. *Demetrias.*
        - not bilobed .... 18. *Dromius.*
  - more or less wide, and depressed. Elytra nearly square. Last joint of the labial palpi
    - strongly securiform. Posterior margin of the thorax
      - forming a right angle with the sides .... 19. *Plochionus.*
      - produced in the middle .... 20. *Aspasia.*
    - not securiform. Posterior margin of the thorax
      - forming a right angle with the sides. Penultimate joint of the tarsi
        - not bilobed .... 21. *Lebia.*
        - bilobed .... 22. *Coptodera.*
- Claws without teeth. Antennæ
  - moniliform, or thickening towards the apex .... 24. *Helluo.*
  - filiform. Upper lip
    - short, transverse, and leaving the mandibles uncovered. Last joint of the labial palpi
      - not securiform. Elytra ovate,
        - more or less elongate
          - wings wanting .... 25. *Aptinus.*
          - winged .... 26. *Brachinus.*
        - scarcely elongate, nearly orbicular .... 27. *Corsyra.*
      - strongly securiform .... 28. *Drepanus.*
    - projecting, and covering the mandibles more or less. The tooth in the notch of the mentum
      - simple. Upper lip quadrate,
        - wider than long. Joints of the four anterior tarsi
          - more or less triangular or heart-shaped .... 29. *Dyscolus.*
          - nearly cylindrical .... 30. *Promecoptera.*
        - longer than broad. Elytra
          - rather short and wide, more or less square or ovate .... 31. *Thyreopterus.*
          - more or less elongate and parallel .... 32. *Catascopus.*
      - wanting. Last joint of the labial palpi
        - rather strongly securiform .... 33. *Eucheyla.*
        - not securiform. Elytra ovate,
          - scarcely elongate, nearly orbicular .... 34. *Graphipterus.*
          - more or less elongate .... 35. *Anthia.*

SECTION 2D, BIPARTITI, Lat. SCARITIDES, Dej.

Almost all the genera of this group (seventeen in number in the system of Dejean) were constituent portions of the old genus *Scarites* of Fabricius and Olivier. They possess several characters in common. The exterior palpi are not subulate or awl-shaped at their extremity. The elytra are not terminated by a truncation, but are either entire or slightly sinuated. The abdomen is separated from the thorax by an obvious intermediate neck-shaped portion.[1] The first article of the antennæ is always the largest. The anterior legs are often broad and palmated, and strongly notched interiorly. The anterior tarsi present no marked disparity in the sexes, and are unprovided with brushes beneath; but simply ciliated.[2]

In the *Coléoptères d'Europe* of MM. Latreille and Dejean, the Scaritides seem to be regarded as not carnivorous. But in opposition to this opinion, so contrary to analogy, we have the authority, as Mr Macleay has noted, of two accurate observers, MM. Olivier and Lefebre de Cerisy. The latter, who resides at Toulon, possesses peculiar facilities for acquiring a knowledge of their natural habits. He states them to be nocturnal insects of prey, which, during the day, lurk motionless in holes of the earth, and sally out at night to attack Melolonthidæ and other insects.[3]

The insects included in this division are rather strongly distinguished from the conterminous groups. As they are destined to live chiefly beneath the surface of the earth, their structure is more peculiarly adapted than that of the other Coleoptera to a subterranean mode of life. The body is narrow, the anterior thighs thickened, the tibiæ dilated, and furnished with strong spines, presenting a broad surface, well fitted to remove the soil;—the head and thorax are strong, and the latter is attached to the abdomen by a short peduncle or footstalk. In the last-mentioned particular they differ from most other pentamerous beetles, which usually have the thorax closely applied to the abdomen, and the hinder angles rectangular or even salient, which necessarily prevents any considerable degree of lateral motion. But in insects which excavate holes scarcely exceeding their body in width, some provision is necessary to enable them to turn their anterior portion in different directions, otherwise their progress would be nearly in a straight line. This object, which is analogous to that which is provided for in moles and other burrowing quadrupeds, by the flexibility of the vertebral column, is attained by the interposition of a narrow cylindrical piece between the abdomen and thorax, on which the latter moves as on a pivot, its hinder angles being rounded off that its motions may be performed with greater facility. The form of the antennæ is likewise in beautiful accordance with the habits of the insects. They are composed of nearly globular articulations attached to each other by a slender filament, bearing some resemblance to a series of beads rather loosely strung. By a structure of this kind, they are rendered greatly more pliant and flexile than in the other Pentamera (the joints of the antennæ in which are generally conical), and therefore present no obstacle to the insect's progress through a resisting medium.[4]

These insects are usually of a uniform black colour. The larva of *Ditomus bucephalus*, the only one that has been attended to, presents, according to Latreille, the same form and habits of life as those of *Cicindelæ*. They are more particularly characteristic of torrid countries, although Great Britain and the rest of Europe produce several genera.

GENUS ENCELADUS, Bon. *Scarites*, Oliv. Mentum inarticulate, soldered, covering almost all the under part of the head, strongly notched, with a bifid tooth in the centre. Terminal article of the labial palpi distinctly securiform. Antennæ filiform; the first article a little longer than the others.

The species of this genus differ from most of their section in having their anterior tibiæ unemarginate, which allies them to the *Simplicimanes* of Dejean, or *Grandipalpi* of Lat. The example figured, *E. gigas* (see Plate CCXXXIV. fig. 4), is a large insect of which the locality seems doubtful. Latreille believed it to come from Madagascar and equinoctial Africa, while Dejean regards it as South American.

GENUS ACANTHOSCELIS, Lat. *Scarites*, Fab. Mentum articulated, almost plane, strongly trilobed. Labrum very short, tridentated. Mandibles large, advanced, strongly toothed interiorly. Terminal article of the labial palpi almost cylindrical. Antennæ moniliform; the first article very large; the others much less, but enlarging insensibly towards the extremity. Body short and convex. Thorax convex, transverse, almost square. Elytra short, and very convex. Anterior tibiæ strongly palmated; posterior short, broad, arched, and spinous. Trochanters almost as large as the posterior thighs.

This genus is formed upon *Scarites ruficornis* of Fab. (Pl. CCXXXIV. fig. 17), an insect above eight lines in length, black, with the palpi and antennæ ferruginous. It is native to the Cape of Good Hope.

GENUS SCARITES,[5] Fab. Mentum articulated, concave, strongly trilobed. Labrum, mandibles, and terminal article of the palpi as in the preceding genus. Body rather elongated, cylindrical, or slightly flattened. Thorax convex, almost crescent-shaped, notched anteriorly, rounded posteriorly, and frequently somewhat prolonged in the middle. Anterior tibiæ strongly palmated, posterior simple. Trochanters much shorter than the posterior thighs.

The insects of our present genus are of considerable size, of a black colour, usually shining, and are characteristic of sandy countries near the sea coast, or of districts impregnated with saline particles. They occur in the warmer countries of Europe, Asia, Africa, and America. Dejean enumerates fifty-eight species. Three are said to occur in Britain, *S. Beckwithii* of Stephens, *S. subterraneus*, and *S. lævigatus*, Fab. The two latter are, however, doubtful natives. The second is in fact an American insect (Plate CCXXXIV. fig, 10),—the third is frequent in the south of France, and along the Mediterranean shores.

GENUS CLIVINA,[6] Lat. *Scarites*, Fab. Mentum articulate, concave, and trilobed. Labium slightly advanced, and cut almost square. Mandibles slightly projecting, not toothed interiorly. Terminal article of the labial palpi almost cylindrical. Antennæ moniliform; the first article as long as the two succeeding united. Body more or less elongated. Thorax square or globular. Anterior tibiæ almost always palmated.

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[1] The foreign genus *Ozæna*, in which the peduncle is scarcely perceptible, may be regarded as an exception to the last-named character.

[2] *Species Général*, t. i. p. 355.

[3] *Annulosa Javanica*, No. i. p. 24.

[4] *Entomologia Edinensis*, p. 77.

[5] From Σκαρίζω, *I run swiftly*.

livina is the name of an augurial bird mentioned by Pliny.

These small insects are usually found under stones, by the banks of rivers, and elsewhere. They are common all over Europe, more especially in its southern parts. They also occur in Africa, America, and the East Indies. We have two British species, *C. fossor*, Gyllenhal, which is brownish black, with the mouth, antennæ, and legs rufous, the elytra punctate striate, of the same colour as the thorax,—and *C. collaris* of Herbst, of which the head and thorax are brownish black, and the elytra chesnut colour. Dejean regards the one as a variety of the other. They are described as distinct by English entomologists. We lately found a rare and interesting species, *C. arctica*, on the mountain range on the north side of the valley of Clova, in Forfarshire. It is known to occur, though rarely, in Lapland, the north of Sweden, Finland, and sometimes as far to the east as the environs of St Petersburg. It forms the genus *Leiochiton* of Curtis,[1] so named from λειος, *smooth*, and χιτον, *a covering*, the upper surface and other parts being remarkable for glossiness.

The genus *Dyschirius*, Bonelli (named from δυς, *two*, and χειρας, *a division of the foot or leg*), which some authors do not admit as distinct from *Clivina*, contains those species of which the thorax is globular, and the anterior tibiæ palmated only at the extremity, and simple exteriorly. Sixteen species are found in Britain.[2]

Genus Ditomus, Bon. Mentum articulated, concave, and trilobed. Labrum slightly notched. Labial palpi slightly elongated, the terminal article almost cylindrical. Antennæ filiform, the articles elongated and nearly filiform. Thorax cordiform or crescent-shaped. Anterior tibiæ not palmated.

This genus was established by Bonelli on the *Scaurus sulcatus*, and certain *Carabi* of Fabricius, which Rossi and Olivier had placed in *Scarites*. The species are of middle size, dark or blackish in their colouring, and frequently deeply punctured. They inhabit the southern parts of Europe, the north of Africa, and the west of Asia. We have figured *D. violaceus* on the plate last referred to, fig. 16. *D. fulvipes* of Lat. a common insect in the south of France, and occurring, though rarely, as far north as Paris, has some claims to be regarded as a British species. We are acquainted with eighteen species in all.

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[1] *British Entomology*, vol. viii. p. 346. Of the genus *Clivina*, including *Dischirius*, &c. Dejean's *Catalogue* enumerates forty-four species.

[2] We take our indications of the amount of indigenous species from Mr Stephens' *Nomenclature of British Insects*. Second edition. 1833.

Coleoptera Pentamera.

Synoptical Table of the preceding Section (Scaritides), *according to the system of Dejean.*

- Mentum inarticulate,
  - nearly covering the under side of the head. Inner side of the anterior tibiæ
    - without a notch.. 1. *Enceladus*
    - strongly notched.. 2. *Siagona.*
  - leaving uncovered a great part of the mouth,
    - broad, very short, and without a perceptible tooth in the centre of its notch..... 3. *Coscinia.*
    - rather narrow, short, and trilobed.. 4. *Melænus.*
- Mentum articulate, leaving great part of the mouth uncovered. Anterior legs
  - palmated. Mandibles
    - strongly dentate on the inner side. Thorax
      - convex, rounded behind, and often a little produced in the middle. Posterior tibiæ
        - straight and nearly simple.. 5. *Scarites.*
        - short, broad, bent, and covered with spines.......................... 6. *Acanthoscelis.*
      - quadrate, and nearly cylindrical.. 7. *Scapterus.*
      - broad, flat, nearly heart-shaped, emarginate posteriorly.......................... 8. *Pasimachus.*
    - very slightly or not at all dentate internally,
      - projecting greatly. Last joint of the labial palpi
        - elongate and pointed.. 9. *Oxystomus.*
        - nearly cylindrical. Thorax nearly
          - square, and somewhat cylindric...10. *Oxygnathus.*
          - heart-shaped, and rather flat..11. *Camptodontus.*
      - projecting very little...12. *Clivina.*
  - not palmated. Antennæ
    - short and nodose. Joints of the antennæ
      - distinct, and scarcely thickening towards the apex.................................13. *Morio.*
      - scarcely distinct, and thickening perceptibly towards the apex.....................14. *Ozæna.*
    - filiform, the joints elongate and nearly cylindrical. Labial palpi
      - somewhat elongate. Anterior tarsi
        - dilated in the males...15. *Carterus.*
        - alike in both sexes..16. *Ditomus.*
      - much elongate..17. *Apotomus.*

SECTION 3D, QUADRIMANI, Lat. HARPALICI, Bon.

In this division Latreille includes those groups of Carabici which, resembling the preceding in the pointed termination of the elytra, have the four anterior tarsi dilated in the males; the first three or four articulations are in the form of a reversed heart or triangle, and are nearly all terminated by acute angles; their under part is usually furnished (excepting the *Aphoni*) with two ranges of papillæ or scales, with an intermediate linear space. The body is always winged, generally oval and arched, or convex above, with the thorax broader than long, or at most nearly isometrical, square, or trapezoidal. The head is never suddenly contracted posteriorly. The antennæ are of equal thickness throughout, or are slightly and insensibly enlarged towards the extremity. The mandibles are never remarkably strong. The external palpi are terminated by an oval or fusiform joint of greater length than that which precedes it. The tooth of the notch or emargination of the mentum is always entire,—in some wanting.[1] The legs are robust, the tibiæ spiny, and the hooks of the tarsi simple. The intermediate tarsi, even in the females, are short, and, with the exception of the dilatation, are formed nearly like the anterior. The species prefer warm and sandy situations exposed to the sun.

GENUS HARPALUS, Lat. Dej. (Pl. CCXXXIV. fig. 11.) The first four articles of the four anterior tarsi strongly dilated in the males, broader than long, and very decidedly triangular, or cordiform. Terminal article of the palpi somewhat elongated, slightly oval, or almost cylindrical and truncated at the extremity. Antennæ filiform. Labrum in the form of a transverse square. Mandibles slightly advanced, arcuated, and not very sharp. A simple tooth, more or less developed, in the middle of the emargination of the mentum. Body oblong, more or less elongated. Head more or less rounded, narrowed posteriorly. Thorax more or less square, cordiform, or trapezoidal. Elytra more or less elongated, and almost parallel.

The genus *Harpalus* of Latreille, as conceived in his *Genera Crustaceorum et Insectorum*, comprised all those insects which Dejean has united in the tribes *Harpaliens* and *Feroniens*, and the genera *Callistus, Oodes, Chlænius, Epomis,* and *Dinodes*, of the *Patellimanes* of the latter author. Bonelli, in his *Observations Entomologiques*, reduced the genus to the insects which now constitute the tribe *Harpaliens* of Dejean, itself consisting of twenty-eight genera. The *Harpalidæ* of the British writers include, besides our present genus, many genera of the sections afterwards mentioned under the names of *Simplicimani* and *Patellimani*.

The genus Harpalus, even as now restricted and above defined, is very extensive, and probably contains nearly one half of the species of the section. The larvæ of these insects, as far as we are acquainted with them, dwell beneath the ground. Their form is conico-cylindrical; their head large, armed with strong mandibles, resembling those of the perfect insect; the posterior part of their body exhibits a membranous tube, terminated by a prolongation of the anal region, and two fleshy articulated appendages. Their metamorphoses are likewise subterranean. The Harpali are distributed over all the earth. They are, however, obviously more abundant in the temperate and even boreal regions of the northern hemisphere, than in equinoctial or southern countries. Comte Dejean's collection contains 179 species, while Mr Stephens enumerates (including the doubtful kinds) 58 species as indigenous to Britain, besides 15 *Ophoni*, which Dejean combines with Harpalus.

We may name as one of the most abundant of the genus *H. ruficornis*, of a pitchy-black colour, the antennæ and legs rufous, the elytra pubescent striated, the interstices punctured. This insect is spread over all Europe. We took it at Cape Wrath. It occurs in Siberia. M. Goudot brought it from Northern Africa.

H. æneus is distinguished by various shades of green above, with a brassy or coppery lustre; the under side black; external margin of the elytra punctulated, the antennæ and legs rufous. This species is extremely variable. It is generally of a rich bronzed green; the males highly polished, the females more obscure, sometimes brownish black. Mr Kirby once took a specimen of this insect, which he immersed in hot water, and was surprised to observe what he at first supposed an intestine thrust itself forth; on a nearer inspection he found it was an intestinal worm, thicker than a horse-hair, and of a brown colour.[2]

This group (the Quadrimani), in the system of Dejean (where it is named Harpaliens), includes many minor genera not recognised in the *Règne Animal*, and contains the genera *Tetragonoderus* and *Pelecium*, which in Latreille's arrangement belong to other sections. As we cannot enter into a detailed exposition of the characters of those genera, we shall here exhibit Dejean's latest views by means of a synoptical table.

HARPALICI.

FIRST SUB-TRIBE.

Mentum trilobed.

Antennæ	filiform	1. *Pelicium.*
	moniliform	2. *Eripus.*

SECOND SUB-TRIBE.

Mentum deeply notched.

This sub-tribe may be separated into two divisions.

FIRST DIVISION.

Antennæ moniliform.

The tooth in the notch of the mentum	simple. Last joint of the labial palpi	ovate	3. *Cratocerus.*
		cylindric, and truncated at the extremity	4. *Somoplatus.*
	wanting		5. *Daptus.*

[1] The ligula or anterior portion of the mentum is always, according to Latreille, in this as well as in the two following genera, remarkably salient, obtuse or truncated at the end, and is accompanied by two distinct membranous paraglossæ in the form of auricles (oreillettes).

[2] For the other British species we must refer the reader to the works of Messrs Stephens and Curtis. We have described such as occur near Edinburgh in our *Entomologia Edinensis*. The characters of the foreign kinds are detailed in Dejean's *Species Général.*

Second Division.

Antennæ filiform.
May be divided into two subdivisions.

First Subdivision.

Notch of the mentum with a bifid tooth in the middle.

- Body
  - flat and rounded .... 6. *Cyclosomus.*
  - elongate .... 7. *Promecoderus.*

Second Subdivision.

Tooth in the notch of the mentum simple or wanting.

- Last joint of the palpi securiform .... 8. *Axinotoma.*
- Last joint of the palpi not securiform. The four first joints of the intermediate tarsi of the males
  - more or less triangular or heart-shaped. Last joint of the palpi
    - more or less cylindric or ovate, and truncated at the extremity. Fourth joint of the four anterior tarsi of the males
      - triangular or heart-shaped. Head
        - more or less quadrate or triangular, not contracted behind. The tooth in the notch of the mentum
          - more or less obvious. Upper lip
            - emarginate. The tooth in the notch of the mentum
              - obtuse .... 9. *Acinopus.*
              - strong and very acute .... 10. *Cratacanthus.*
            - quadrate .... 11. *Paramecus.*
          - wanting. Mandibles
            - more or less pointed. Upper lip
              - deeply notched .... 12. *Cratognathus.*
              - almost quadrate .... 13. *Agonoderus.*
            - obtuse, and not salient .... 14. *Barysomus.*
        - more or less rounded and triangular, and contracted behind. The tooth in the notch of the mentum
          - wanting. Mandibles
            - obtuse, and not salient .... 15. *Amblygnatus.*
            - more or less pointed. Four first joints of the anterior tarsi of the males
              - obviously dilated. First joint of the four anterior tarsi of the males
                - as wide as the following. Last joint of the palpi
                  - ovate and almost inflated. First joint of the anterior tarsi of the females
                    - not dilated ... 16. *Platymetopus.*
                    - dilated .... 17. *Gynandropus.*
                  - cylindric, or very slightly ovate 18. *Selenophorus.*
                - smaller than the following .... 19. *Anisodactylus.*
              - very slightly dilated .... 20. *Bradybænus.*
          - more or less obvious. Mandibles
            - salient and pointed .... 21. *Geodromus.*
            - projecting but little. The four first joints of the intermediate tarsi of the males
              - obviously dilated. The four first joints of the four anterior tarsi of the males
                - as long as wide, and slightly triangular .. 22. *Hypolithus.*
                - wider than long, and distinctly triangular or heart-shaped. First joint of the anterior tarsi of the females
                  - dilated .... 23. *Gynandromorphus.*
                  - not dilated .... 24. *Harpalus.*
              - very slightly dilated .... 25. *Geobænus.*
      - deeply bilobed .... 26. *Stenolophus.*
    - terminating in a point .... 27. *Acupalpus.*
  - broad and nearly square .... 28. *Tetragonoderus.*

SECTION 4TH, SIMPLICIMANI.

This section resembles the preceding so far as regards the termination of the elytra;[1] but the two anterior tarsi only are dilated in the males, without however forming a square or orbicular pallet; sometimes the first three articles are obviously broader, and the succeeding one is in that case always much less than its antecedent; sometimes the latter and the two preceding ones are larger, almost equal, and in the form of a reversed or triangular heart. The joints of the four following tarsi are more slender and elongated, almost cylindrical, or in the form of a lengthened and reversed cone.

The *Simplicimani* of Latreille consist of genera belonging to the tribe *Carabiques Feroniens* of Dejean, with the addition of *Tetragonoderus*, Dejean (Harpalici), *Catascopus*, Kirby (Truncatipennes), and a few others.

GENUS ZABRUS, Clairville. The first three articles of the anterior tarsi dilated in the males, broader than long, strongly cordiform. Terminal article of the palpi almost cylindrical, and truncated at the extremity. Antennæ filiform, and but slightly lengthened. Labrum of a square form, broader than long, slightly notched anteriorly. Mandibles little advanced, rather strongly arcuated, almost obtuse. A simple tooth in the middle of the emargination of the mentum. Body thick and convex. Thorax transverse, square, trapezoidal, or rounded on the sides. Elytra convex, rarely elongated, frequently very short, almost parallel, and rounded at the extremity.

These insects are usually found under stones, or marching about the fields, occasionally on the stalks of grass or other herbage. We are acquainted with about twenty species, of which not more than two are British. The majority of the others occur in the southern parts of Europe. There is one from Teneriffe.

GENUS FERONIA, Lat. Dej. The first three articles of the anterior tarsi dilated in the males, broader than long, and strongly triangular or cordiform. Terminal article of the palpi more or less elongated, cylindrical, or slightly securiform. Antennæ filiform, more or less lengthened. Labrum square, broader than long, sometimes almost transversal, quadrate anteriorly, or slightly notched. Mandibles more or less advanced, and more or less arcuated and pointed. A bifid tooth in the middle of the emargination of the mentum. Thorax more or less cordiform, rounded, square, or trapezoidal, never transverse. Elytra more or less elongated, oval, or parallel. Intermediate tibiæ always straight.

A great variety of opinion is maintained by entomologists regarding the distribution of the component parts of this extensive genus. Bonelli, in the synoptical table annexed to the first part of his *Observations Entomologiques* (in 1809), published the generic characters of *Platysma*, *Pæcilus*, *Abax*, *Molops*, *Percus*, *Melanius*, and *Pterostichus*. At an after period MM. Megerle and Ziegler established *Argutor*, *Steropus*, *Cophosus*, and *Omaseus*, the latter genus, it is believed, corresponding to *Melanius* of Bonelli. All these were admitted provisionally into the first edition of Comte Dejean's *Catalogue*, published in 1821. In the third volume, however, of the *Species Général* of that great collector, he observes as follows: "Ma collection depuis cette époque s'etant considérablement augmentée, je me suis trouvé souvent tres-embarassé pour placer dans ces différents genres les espèces qui je recevais, surtout les exotiques, et quelquefois plusieurs d'entre elles me paraissaient intermédiaires entre deux genres, et appartenir autant à l'un qu'à l'autre. Plus je recevais d'insectes, plus je me trouvais embarassé, et lorsque je voulus classer definitivement toutes mes espèces dans chaque genre, et etablir les caractères de chacun de ces genres, après plusieurs essais infructueux, je finis par être convaincu que cela était réellement impossible." Dejean then thought of following the example of Sturm, who reduces (in his *Deutschlands Fauna*) all the genera above named to those of *Abax*, *Molops*, *Pterostichus*, and *Platysma*; but after a deliberate re-examination, even these did not appear sufficiently marked; and he finally determined to combine them all in one under the name of FERONIA, a term previously used in a comprehensive sense by Latreille in the first edition of the *Règne Animal*.

The genus *Feronia*, then, of Dejean is one of the most extensive in the coleopterous order, containing above 230 species. It is subdivided by the last-named author into ten sections, corresponding to the same number of genera as established by Bonelli, Megerle, Ziegler, and Sturm.

According to Latreille's views, the genus is divisible into three groups as follows: 1*st*, The species, generally winged, of which the body, more or less oval, is a little convex or arcuated above, with the antennæ more filiform, the head proportionally narrower, and the mandibles somewhat less projecting. In their habits these insects approach the genera *Harpalus* and *Zabrus*. Such are the *Amaræ*, of which the thorax is transverse (and which Dejean admits as a distinct genus); the *Pæcili*, where it is almost as long as broad, and where the rather short antennæ have the third article compressed and angular; and the *Argutores*, which resemble the Pæcili, but have proportionally shorter antennæ, with the third joint not angular.

2*d*, The species usually furnished with wings, but of which the body is straight, plane, or horizontal above, with the head nearly as wide as the body. Such is the genus *Platysma* of Bonelli, to which Latreille unites *Omaseus* of Ziegler and Dejean, and *Catadromus* of Macleay.

3*d*, This division contains Feroniæ, analogous to those of the preceding one in their general characters, but distinguished by the want of wings.[2]

We shall conclude by observing that our English entomologists have adopted all those minor genera, in so far as they are applicable to the British species, and have even proposed several others of still more limited application. We regret that our necessarily narrow limits prevent our entering into minute details.[3] We shall merely indicate a few of the species. *F. madida* is shining black, the elytra ovate, rather convex, subpunctate-striate, with a puncture on the third interstice a little behind the middle. This is the *F. concinna* of Sturm and Dejean. A variety occurs with the thighs and sometimes the tibiæ rufous; it constitutes the *F. madida* of the latter author. They are not distinct. Both varieties are in this country among the most common of coleopterous insects, occurring beneath stones, at the roots of trees, &c. both on low grounds and on mountains. They seem less common in Germany than in any other country in Europe. *F. nigrita* is also of frequent occurrence in all parts of Britain. It is of a shining black, the thorax subquadrate, narrowed behind, the elytra with obsoletely punctured striæ, and three impressed dots on the disk. *F. orinomum* is like-

[1] As usual, there are exceptions to the rule:—"Plusieurs Carabiques simplicimanes," says Latreille, "ont l'extrémité de leurs élytres fortement sinuée au bout, et se distinguant à peine, sous ce rapport, des *Troncatipennes*." (Note to *Règne Animal*, t. iv p. 399.)

[2] For a further exposition of Latreille's views, see *Règne Animal*, tom. iv. p. 395.

[3] For the arrangement of the indigenous species, see Mr Stephens' *Nomenclature of British Insects*, 2d edition.

wise shining black, often faintly tinged with brassy; elytra striated, with more than four impressed dots on the disk of each. By the comparison of an extensive series of specimens of this insect which we have collected in various parts of Scotland, we are satisfied that *F.* (*Omaseus*) *Bulwerii* of Stephens is not specifically distinct. A species frequent under stones in woods and fields, and the last which we shall here mention, is *F. melanaria.* It is black, apterous, moderately convex, the thorax with a bistriated fovea in each of its posterior angles, the elytra with striæ nearly impunctate.

Genus Broscus, Panzer. *Cephalotes*, Bon. First three articles of the anterior tarsi dilated in the males, broader than long, and decidedly cordiform. Terminal article of the labial palpi elongated and slightly securiform. Antennæ filiform, and but slightly lengthened. Labrum of a square form, broader than long, almost transverse. Mandibles slightly arcuated, and rather sharp. A simple tooth in the middle of the emargination of the mentum. Thorax cordiform, convex, and much contracted posteriorly. Elytra rather long, slightly oval, or parallel.

This genus was established by Bonelli on the *Carabus cephalotes* of Fabricius, and was also distinguished about the same period by Panzer under the name of *Broscus.* We adopt the latter term as more familiar to the English collectors. Of the five species with which we are acquainted, two belong to Europe, one to the north of Africa, one to Mount Sinai, and the fifth to Asia Minor. They are all of considerable size, and bear a resemblance to the genus *Steropus* of Megerle.

The only British species is *B. cephalotes*, which is of an elongated form, black, with the head thinly punctured, and the elytra very finely punctate-striate. It occurs in sandy places over many parts of Britain; and in the vicinity of Edinburgh is plentiful under stones, and marine rejectamenta, on the shore between Portobello and Musselburgh. We found it as far north as Keoldale, near Cape Wrath. The attitude this insect assumes when disturbed is rather peculiar. The two anterior pair of legs are brought close together, and extended straight outwards at right angles with the under surface of the body. The hind legs are bent upwards, and project in a similar way from the opposite surface. The antennæ are drawn close to the sides of the thorax, and the mandibles extended to their utmost stretch, while a considerable degree of rigidity is imparted to the whole. It takes this posture most readily in cold weather; at other times, when more active, it prefers seeking safety by flight, or by burrowing in the sand.[1]

" The habit of these insects," it is elsewhere observed, " is very curious. They are found only in the sand on the sea shore, and live in dens about three inches deep and half an inch wide, which are made in a diagonal position in the sand, where it is mixed with decomposed stalks of *Elymus arenarius.* They appear to rove during the day occasionally; but upon any alarm they run swiftly to their dens, projecting from the mouths of which their heads may be seen watching for prey. On holding another beetle to the hole, the one within would immediately seize hold of it with its jaws, and continue so tightly fixed as to suffer itself to be drawn out without quitting its hold. They appear to be very ferocious insects; and, from the number of elytra and other parts strewed about the sand, it may be supposed that they prey on each other."[2] The latter observation, we may remark, applies to many insects; although the human race (certainly in that respect the most noted) have been supposed to present the only instances of identical species waging war upon each other.

> Even tiger fell and sullen bear,
> Their likeness and their lineage spare.
> Man only mars kind nature's plan,
> And turns the fierce pursuit on man.[3]

The natural position of the genus Broscus seems to be that assigned it by Mr Curtis, between the Scaritides and the species which in the *Entomologia Edinensis* is placed at the head of the genus *Feronia*, viz. *F. madida* (*Steropus madidus*, Meger.). In common with the former, *Broscus* possesses an elongated form, rather short stout legs, and a pedunculated thorax, which adapt it to a subterraneous mode of life. In the latter the thorax is also pedunculated, and the legs thick and strong, while the more rigid structure of the antennæ, admitting less easily of being applied to the sides of the thorax to facilitate progression in a cylindrical hole, together with the general configuration of most of the other parts, assimilate it more decidedly to the other Feroniæ, to which its habits perfectly correspond.

Genus Mormolyce, Hagenbach.[4] Exterior palpi very short; the terminal article cylindrical, and almost rounded at the extremity. Antennæ setaceous, almost as long as the body; the third article as long as the two following. Labrum almost square, notched anteriorly. Mandibles short, arcuated, rather sharp, and toothed interiorly. A simple tooth in the middle of the emargination of the mentum. Body remarkably depressed. Head narrow, elongated, much prolonged posteriorly. Thorax almost lozenge-shaped. Elytra flat, thin, greatly dilated, much wider and longer than the abdomen.

The aspect of this genus is one of the most remarkable with which we are acquainted. We place it among the *Simplicimani* (*Feroniens*) in accordance with the example of Latreille and Dejean, the latter of whom observes, " J'ai placé cet insecte près des *Sphodrus*, mais ce n'est que provisiorement, car j'ignore de quelle maniere les tarses sont dilatés dans les males, et même s'ils ne sont pas semblables dans les deux sexes." In regard to its locality he further observes, " D'après M. Hagenbach, elle se trouve dans la partie occidentale de Java; d'autres personnes croient qu'elle vient de la Cochin-Chine."[5] Our recent acquisition of an extensive series of specimens of the only known species enables us to determine both of those doubtful points. The tarsi are alike in both sexes, and our collection was brought from Java.

The insect above alluded to (*Mormolyce phyllodes*, Plate CCXXXIV. fig. 13[6]) measures nearly three inches in length and an inch and a half across the dilated portion of the elytra. It is entirely of a blackish-brown colour, somewhat paler on the edges of the abdomen. It is furnished with wings, and the elytra have the appearance of being reticulated. The figure just referred to will convey an accurate idea of its form. We have supplied the principal collections of Europe with this rare and singular insect, of which, says Dejean, to whom we had the pleasure to transmit a pair, " il est presque impossible de se faire la moindre idée par la description." He also terms it " un insecte extraordinaire, qui parait appartenir au premier aspect à la famille des *Mantis*, mais qui est cependant un Coléoptère, et même un veritable Carabique, ainsi qu'il est facile de s'en convaincre par ses caractères generiques."

Passing over the genus *Sphodrus*, of which *S. leucophthalmus* is the only British species, we come to

Genus Calathus, Bon. First three articles of the

[1] *Entomologia Edinensis*, p. 82. [2] *Entomological Magazine*, No. 1, p. 92. [3] *Rokeby*, canto iii.
[4] *Mormolyce Novum Coleopterorum Genus*, Nuremberg, 1825. [5] *Species Général*, t. v. part 2, p. 714.
[6] The parts of the mouth are represented on the same plate, fig. 12, *a*, *b*, *c*, *d*.

Coleoptera Pentamera.

anterior tarsi dilated in the males. Hooks of the tarsi toothed beneath. Terminal article of the palpi elongated, almost cylindrical, and truncated at the extremity. Antennæ rather elongated, filiform, and slightly compressed. Labrum of a square form, broader than long, very slightly notched anteriorly Mandibles not much advanced, slightly arcuated, and rather sharp. A bifid tooth in the middle of the emargination of the mentum. Thorax trapezoidal, or almost square, little, if at all, contracted posteriorly. Elytra rather elongated, slightly oval, little contracted anteriorly, and rounded at the extremity.

This genus, as Mr Stephens observes, presents a peculiar outline from the shape of the head, trapeziform thorax, and elliptic elytra, by which it is readily distinguished from the neighbouring genera. The species usually reside among short herbage on banks, and are frequently observed upon quick-hedges.[1] They are generally of a black or brown colour, rarely metallic. They are extremely active in their movements. The only species we shall here notice is the *C. microcephalus* of Dejean,[2] which we discovered in the summer of 1832 in the highlands of Forfarshire, Perthshire, and Aberdeenshire. It forms an addition to our British species, and is distinguishable from the others by the following characters:—Shining black; antennæ, palpi, legs, and margin of the thorax testaceous; the thorax rather long, somewhat narrowed behind, with the hinder angles obtuse; elytra not much elongate, with slender impunctate striæ, the second and third from the suture with two impressed points. In size it nearly agrees with the very common *C. melanocephalus*. On the continent it occurs in Sweden, France, Switzerland, and Germany, chiefly in woods and on mountains.

Here follows the synoptical table of the preceding section, according to the system of Dejean, and including many genera of which we cannot give the detailed characters.

FERONIENS, Dej. (Chiefly) SIMPLICIMANI, Lat.

DIVISION FIRST.

First joint of the anterior tarsi dilated, at least in the males.

This division contains only one genus........ 1. *Stenomorphus.*

DIVISION SECOND.

The two first joints of the anterior tarsi dilated in the males.

Tooth in the notch of the mentum	wanting			2. *Omphreus.*
	simple			3. *Melanotus.*
	bifid. Last joint of the labial palpi	ovate, and terminating nearly in a point. Thorax	flat, nearly square, slightly or not at all contracted behind	4. *Pogonus.*
			convex, heart-shaped, considerably contracted behind	5. *Cardiaderus.*
		nearly cylindrical, truncated at the tip, and slightly securiform. Thorax	convex, nearly ovate	6. *Baripus.*
			flat, contracted behind, more or less heart-shaped	7. *Patrobus.*

DIVISION THIRD.

Three first joints of the anterior tarsi dilated in the males.

FIRST SUBDIVISION.

Claws dentate beneath.

Tooth in the notch of the mentum	simple			8. *Dolichus.*
	bifid. Last joint of the labial palpi	not securiform. Thorax	contracted behind, and more or less heart-shaped	9. *Pristonychus.*
			trapezoidal or nearly square; scarcely or not at all contracted behind	10. *Calathus.*
			oval, rounded behind	11. *Pristodactyla.*
		securiform		12. *Taphria.*

[1] *Illus. of Brit. Ent.* vol. i. p. 98.

[2] *Species Général*, t. iii. p. 78.

Coleoptera Pentamera.

SECOND SUBDIVISION.

Claws without teeth.

- Third joint of the antennæ as long as the two following united. Elytra
  - much wider than the abdomen..13. *Mormolyce.*
  - nearly of the same breadth as the abdomen..14. *Sphodrus.*
- Third joint of the antennæ shorter than the two following united. Three first joints of the anterior tarsi in the males
  - considerably elongate, very slightly triangular, or nearly square. The tooth in the notch of the mentum
    - simple. Thorax more or less
      - heart-shaped; the hinder angles always distinct. Elytra
        - flat, elongate-ovate, without distinct anterior angles........15. *Platynus.*
        - slightly convex, ovate or elongate-quadrate; the anterior angles always distinct..16. *Anchomenus.*
      - rounded; without distinct posterior angles..17. *Agonum.*
    - wanting..18. *Olisthopus.*
  - scarcely elongate, distinctly triangular or heart-shaped. Mentum
    - trilobed or slightly notched. Last joint of the maxillary palpi
      - not securiform,
        - almost cylindrical, and truncated at the tip. Last joint of the labial palpi
          - triangular, or very strongly securiform..19. *Trigonotoma.*
          - slightly securiform. Middle lobe of the mentum
            - produced and nearly pointed..20. *Catadromus.*
            - scarcely produced and almost truncated..........21. *Lesticus.*
          - almost cylindrical. Middle lobe of the mentum
            - nearly wanting..22. *Distrigus.*
            - rounded..23. *Abacetus.*
        - elongate, and terminating nearly in a point..24. *Drimostoma.*
      - strongly securiform..25. *Microcephalus.*
    - deeply notched. The tooth in the notch
      - simple or bifid. Three first joints of the anterior tarsi of the males
        - without appendages beneath. Last joint of the maxillary palpi
          - cylindric or securiform. Body
            - more or less elongate or depressed; Thorax more or less heart-shaped, rounded, quadrate, or trapezoidal. The tooth in the notch of the mentum
              - bifid. Last joint of the labial palpi
                - not securiform. Middle legs
                  - not at all or slightly arched..................26. *Feronia.*
                  - much arched..............27. *Camptoscelis.*
                - strongly securiform..............28. *Myas.*
              - simple. Thorax
                - convex or heart-shaped. Mandibles
                  - wide, and projecting little....................29. *Cephalotes.*
                  - narrow, and projecting much....................30. *Stomis.*
                - flat and nearly square..............31. *Abaris.*
            - short, thick, and convex; thorax transverse. Last joint of the labial palpi
              - pretty strongly securiform........................32. *Rathymus.*
              - nearly cylindrical. The tooth in the notch of the mentum
                - bifid..33. *Pelor.*
                - simple..34. *Zabrus.*
          - slightly ovate..35. *Amara.*
        - furnished with appendages beneath..36. *Lophidius.*
      - wanting. Thorax
        - more or less square or heart-shaped, not at all or very slightly transverse 37. *Antarctia.*
        - transverse, rounded on the sides, slightly produced in the middle behind..38. *Masoreus.*

SECTION 5TH, PATELLIMANI, Lat.

This section is chiefly distinguished from the preceding by the mode in which the two anterior tarsi are dilated in the males; the first joints (usually the first three, then the fourth, in others only the first two) sometimes square, sometimes partly of that form, and the others heart-shaped or reversed triangular, but always rounded at their extremity, and not terminated, as in the preceding sections, by acute angles,—form an orbicular pallet or lengthened square, of which the under surface is usually furnished with brushes or close set papillæ, without any intermediate vacancy. The legs are generally long and slender. The thorax is frequently narrower throughout its whole extent than the abdomen. The species frequent, for the most part, moist places on the banks of rivers.

In the *Règne Animal* this section is composed of the *Patellimani* of Dejean, of a portion of his *Feroniens* (Gen. *Dolichus*, *Platynus*, *Agonum*, *Anchomenus*, *Patrobus*), and of the genus *Pelicium* of Kirby, referred to the *Harpaliens* in the *Species Général*. It is subdivided by Latreille into two principal groups.

a. Head insensibly contracted behind.

GENUS AGONUM, Bon. First three articles of the anterior tarsi dilated in the males, longer than broad, and slightly triangular or cordiform. Terminal article of the palpi lengthened, cylindrical, more or less oval, and truncated at the extremity. Antennæ filiform, rather elongated. Labrum slightly convex, of a square form, broader than long, almost transversal. Mandibles not much advanced, slightly arcuated, rather sharp. A simple tooth in the middle of the emargination of the mentum. Thorax more or less rounded, without obvious posterior angles. Elytra oval, more or less elongated.

Of this genus *A. sexpunctatum* is a beautiful species, of which the head and thorax are golden green, the elytra copper-red, finely striated, and impressed with six large punctures. There is only one recorded instance of its being taken in Scotland,—on the banks of the water of Leith, a little to the west of Edinburgh.[1] Several other species are, however, common in Scotland. There are about thirty kinds in Britain; and Dejean's collection contains fifty-six.

The genus ANCHOMENUS is nearly allied to the preceding, but the labrum is plane, the thorax more or less cordiform, with obvious posterior angles. The body is not so flat. We are acquainted with above forty kinds, of which not more than five inhabit Britain. We consider *Platynus angusticollis* as belonging to this genus.

In the genus CHLÆNIUS of Bonelli, the tooth of the emargination of the mentum is bifid, the external maxillary palpi are terminated by an almost cylindrical article, slightly restricted at the base, that of the labial being in the form of a reversed and lengthened cone. There are 115 species of this extensive genus, of which about eight are as yet recognised as British. They are ornamental insects, being frequently adorned with green, and burnished with a metallic lustre. They are spread over almost all the earth,—Europe, Asia, Africa, and America. They seem, however, rare in the southern division of the new world, and, as far as we know, have not yet been found in New Holland.[2] *Carabus saponarius* of Olivier,[3] which is used in Africa instead of soap, belongs to the genus *Chlænius*. It was brought from Senegal by M. Geoffroy, fils.

In the genus LICINUS the first two articles of the anterior tarsi are dilated in the males. The terminal article of the palpi is broad and securiform, and there is no tooth in the middle of the emargination of the mentum. The species are confined to Europe and the north of Africa. In the genus BADISTER the first three articles of anterior tarsi are dilated in the males, and the terminal article of the palpi is oval. The species are confined to Europe.

b. Head suddenly contracted behind the eyes.

This division of the *Patellimani* contains the genera PELICIUM of Kirby and CYNTHIA of Lat., both from South America, and three other genera, viz. PANAGÆUS (see Pl. CCXXXIV. fig. 15), of which the head is very small compared to the size of the body,—LORICERA (Ibid. fig 14), of which the first joint of the antennæ is robust, almost as long as the three following united, the second and fourth short, with strong hairs, the third longer than the second, likewise furnished with hairs,—and PATROBUS.

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[1] *Ent. Ed.* p. 99.

[2] For the sectional division of this genus, see Dejean's *Species Général*, t. ii. p. 297.

[3] *Coléoptères*, t. iii. p. 35, Pl. 3. fig. 26.

Synoptical Table of the preceding Section, according to the System of Dejean.

PATELLIMANI.

- Notch of the mentum with a tooth in the middle. Anterior tarsi dilated in the males
  - at most in the two first joints. Last joint of the maxillary palpi
    - strongly securiform. The tooth in the notch of the mentum
      - simple .... 1. *Eurysoma.*
      - bifid .... 2. *Panagæus.*
    - not securiform .... 3. *Geobius.*
  - in the three first joints. The tooth in the notch of the mentum
    - simple. Antennæ
      - beset with hairs .... 4. *Loricera.*
      - simple. Last joint of the palpi
        - not securiform,
          - rather elongate, ovate, and terminating nearly in a point .... 5. *Callistus.*
          - elongate, and truncated at the tip .... 10. *Oodes.*
        - strongly securiform .... 6. *Vertagus.*
    - bifid. Last joint of the palpi
      - elongate, and
        - truncated at the apex .... 7. *Chlænius.*
        - strongly securiform .... 8. *Epomis.*
      - short and slightly securiform .... 9. *Dinodes.*
- Notch of the mentum without tooth in the middle. Mandibles
  - pointed. Last joint of the palpi
    - not securiform .... 11. *Rhembus.*
    - rather strongly securiform .... 12. *Dicælus.*
  - obtuse. Anterior tarsi dilated in the males,
    - in the two first joints .... 13. *Licinus.*
    - in the three first joints .... 14. *Badister.*

**

Anterior tibiæ without an emargination on the internal side, or presenting one that begins close to their extremity, or that does not extend on their anterior face, and forms merely an oblique and linear canal.

SECTION 6TH, GRANDIPALPI, Lat. SIMPLICIPEDES, Dej.

In this section of the *Carabici* the ligula is often extremely short, terminated in a point in the centre of its summit, and accompanied by pointed paraglossæ. The mandibles are robust. The terminal joint of the exterior palpi is usually larger, compressed into the form of a reversed triangle, or hatchet-shaped in some,—almost spoon-shaped in others.[1] The eyes are prominent. The elytra are entire, or simply sinuated at their posterior extremity. The abdomen is usually bulky when compared to the other parts of the body. These Carabici are for the most part of great size, often richly coloured, or ornamented with metallic splendour. They are active in their movements, and voracious in their dispositions. They are divisible into three groups.

1*st*, Body always thick, without wings; labrum always bilobed; terminal article of the external palpi always very large; emargination of the mentum toothless; internal side of the mandibles entirely dentated (or nearly so) throughout their length.

GENUS PAMBORUS, Lat. Tarsi similar in both sexes. Terminal article of the palpi securiform. Antennæ filiform. Labrum bilobed. Mandibles but slightly projecting, greatly curved, strongly toothed interiorly. Mentum almost plane, slightly notched anteriorly. Thorax almost cordiform. Elytra elongate oval.

This genus is formed upon a large insect from New Holland, the *P. alternans*, which we have represented in Pl. CCXXXV. fig. 1. It is the only one yet known. In a collection received some time ago from New Holland (transmitted to the Edinburgh Museum by Colonel Lindsay), and submitted to our examination by Professor Jameson, there is either a distinct species, or a strongly marked variety,—the third and fourth striæ of the elytra being much more regular than usual. Comte Dejean, with whom we communicated on the subject, regards it as a species.

GENUS CYCHRUS, Fab. Tarsi similar in the two sexes. Terminal article of the palpi very strongly securiform, almost spoon-shaped, and more dilated, in the males. Antennæ setaceous. Labrum bifid. Mandibles narrow, and toothed interiorly. Mentum strongly notched. Thorax cordiform, little, if at all, raised at the edges, and not prolonged posteriorly. Elytra fixed, carinated laterally, and embracing the sides of the abdomen.

C. *rostratus* is common all over Britain, and is sometimes taken at a great height upon the mountains. *C. elongatus* and *attenuatus* are said to occur in England. We have represented that discovered by Professor Bonelli among the mountains of the north of Italy, Plate CCXXXIV. fig. 22. Eleven species are known in all. They are found in Europe, Asiatic Russia, and North America.

The genus SPHÆRODERUS of Dejean is formed by dismemberment of the preceding. It is a sub-genus peculiar to America. We have represented *S. nitidicollis*, Plate CCXXXIV. fig. 19.

2*d*, Body thick, and mostly apterous, as in the preceding genera, but the emargination of the mentum provided with an entire or bifid tooth, and the mandibles armed at most with one or two teeth situated at their base.

GENUS PROCERUS, Megerle. Tarsi similar in both sexes. Terminal article of the palpi very strongly securiform, and more dilated in the males. Antennæ filiform. Labrum bilobed. Mandibles slightly curved, very sharp, smooth, with only a single tooth at their base. A very strong tooth in the middle of the emargination of the mentum. Thorax almost cordiform. Elytra elongate oval.

The Proceri are large and remarkable insects, the giants of the European Carabici. In regard to their colours, they are either entirely black, or black beneath, with a tinge of blue or green above. The elytra are extremely rough. They appear to inhabit exclusively the mountains and forests of Carniola, Illyria, Turkey in Europe, parts of Hungary, the south of Russia, the Caucasus, and Asia Minor. *P. Duponchelii*, Dej. was lately taken in the environs of Athens. M. Fischer is of opinion (*Entomographie de la Russie*), that *P. tauricus* (Pl. CCXXXIV. fig. 21) and *Caucasicus* are, the former the male, the latter the female, of the same species; but Dejean now possesses both sexes of each, and regards them as distinct. The synonymes of the species, however, are still confused and contradictory.

GENUS CARABUS, Lin. Fischer, Dej. The first four articles of the anterior tarsi dilated in the males, the first three very strongly, the fourth often more slightly. Terminal article of the palpi more or less securiform, and more dilated in the males. Antennæ filiform; the third article cylindrical, and scarcely longer than the others. Labrum bilobed. Mandibles slightly curved, more or less sharp, smooth, with only a single tooth at their base. A very strong tooth in the middle of the emargination of the mentum. Thorax more or less cordiform. Elytra more or less elongate oval. Wings not fitted for flight.

The great genus *Carabus* of Linnæus originally contained the whole of those extensive natural groups which now constitute the family of Carabici, with which we are still engaged. Even as now restricted, it is one of the most numerous with which the entomologist is concerned, and is rendered highly interesting from the size and beauty of many species. The genera with which the *Carabi*, as above defined, bear the most direct relations, are *Procerus, Procrustes, Calosoma;* but, as Dejean observes, they differ from the first by the anterior tarsi, dilated in the males,—from the second by the form of the labrum and mentum,—and from the third by several characters easily perceived on comparison.

The greater proportion of the true Carabi, which form a very interesting and well-observed genus, occur in the comparatively temperate countries of Europe, the Caucasus, Siberia, Asia Minor, Syria, and the north of Africa, as far south as the 30th degree. A few are also found towards the two extremities of America, and it is not improbable that others may be ascertained to inhabit the intermediate countries.[2] A very fine species (*C. cribellatus*, Adams) is native to the polar regions of Siberia;[3] and Sir Joseph Banks captured another as far south as Terra del Fuego;[4] of the latter circumstance, Dejean, who has done so much to illustrate the family, does not appear to be aware. "Depuis long temps je supposais néanmoins qu'on devait les retrouver à l'extrémité de l'Amérique Méridionale; M. Eschscholtz, qui fait pour la seconde fois le tour du monde avec le Capitaine Kotzebue, vient de confirmer cette supposition, et dans une lettre écrite à M. le Comte de Mannerheim il lui annonce

[1] It is often more dilated in the males than in the other sex, particularly in *Procerus*.

[2] *Règne Animal*, t. iv. p. 412.

[3] *Entomographie de la Russie*, tab. 8, fig. 13.

[4] *Introduc. to Ent.* vol. iv. p. 493.

qu'il a trouvé au Chili un véritable Carabe."[1] None of the genus, however, has as yet been found either in Southern Africa or New Holland. Count Dejean possesses 163 species, which he has arranged in sixteen divisions. In the first thirteen are comprised all those of which the elytra are arched or convex, in the three last those in which they are plane. The nature of the surface of the elytra furnishes the other secondary characters, in pretty close accordance with the methods of Bonelli and Clairville.[2] Among the continental species, the *C. rutilans* (Pl. CCXXXIV. fig. 20), *hispanus*, &c. exhibit perhaps the most ornamental examples within the range of the European Coleoptera; and our own *Carabus nitens*, an inhabitant of the heathy wastes, yields to few, even of the exotic species, in its lustrous and metallic splendour.

The name of Carabus (Καραβος), applied generically by Linnæus to so vast a group, occurs in Aristotle's history of animals, and denotes sometimes a winged coleopterous insect, at other times a species of crustaceous animal. Latreille supposes it to be a contracted form of *Scarabæus*. In addition to the characters already given, we may mention that the species of the genus, as now restricted, are all of considerable dimensions. Their colours are usually black with a tinge of purple, or greenish with a golden hue. The form of the body is elongated; the head, always narrower than the thorax, is generally of greater extent forwards than transversely, and is borne almost in a horizontal position. The eyes are globular, and behind them the head assumes a narrow neck-like form. The mandibles, which are strong and pointed, are usually destitute of dentation, and may be observed to cross each other when the insect is in a state of repose. The thorax is narrower than the abdomen, is bordered with a slightly recurved margin, and is almost always emarginate in its basal line; its superior portion (strictly speaking the *prothorax*) is more extended than the inferior parts, and covers posteriorly the scutellum of the mesothorax, which, naturally but slightly developed, presents to view its summit only. The elytra are also margined after the manner of the thorax, and their upper surface, rarely smooth, is variously characterized, according to the species, by striæ, furrows, depressed points, or rows of bead-like elevations. The true or membranaceous wings are either wanting or exist in a very rudimentary condition. The species therefore are incapable of flight; but, to make amends for this deficiency, their legs are strong and lengthened, the trochanter is greatly developed, and the tarsi of the anterior pair (in the males) are dilated, with their first four articulations spongy on their inferior face.

All the species are eminently voracious and carnivorous. They not only prey upon the soft bodied and defenceless caterpillars, and on all other insects weaker than themselves, but they even seize upon and devour their own species. They usually avoid strong light, are partial to a certain degree of moisture, and conceal themselves during the heat of the day beneath stones, among mossy herbage, in garden rubbish, or under the stems or within the hollows of fallen trees. We have noted the usual habits of each of the species in the descriptions which follow; and, in regard to their general distribution, we may observe, that their principal seat appears to be the north temperate zone, that they are extremely rare in the warmer regions of the earth, and probably disappear altogether within the tropics. Their larvæ and metamorphoses are but slightly known. Many of the perfect insects exhale a penetrating and fetid odour, and when touched exude a dark-coloured caustic humour.

Mr Stephens enumerates nineteen species of British Carabi. The claims, however, of three or four of these (such as *C. purpurascens, convexus, auronitens*) to be regarded as truly indigenous, are extremely doubtful. The occurrence of an insect on our island shores is sometimes accidental, and results from the fortuitous impulsion of winds or waves. It is well that the visits of these erratic strangers should be recorded, as they afford an interesting illustration of the extreme extent in one direction of their geographical range; but they cannot on that account be considered as " children of the soil." We shall here give a few brief notices of the Scottish species.

C. *catenalatus*, Fab. Oblong-ovate, black, the margins of the thorax and of the elytra violaceous; elytra with interrupted crenated striæ, and three rows of impressed dots, the spaces between the dots slightly elevated. Common throughout Scotland, both on mountains and in plains.

C. *monilis*, Fab. Oblong-ovate, thorax coppery, elytra brassy-green or violaceous, with three series of oblong tubercles, and three equal elevated lines between them. The colour of this species is very variable. It is rare in Scotland, and we have not yet observed it during our excursions to the northern counties.

C. *arvensis*, Fab. Ovate, greenish coppery, or brassy above, elytra with three series of oblong tubercles, and three crenulated lines between them, the central line rather elevated. Not as yet known to be generally spread over Scotland, but collected at several distant points. Pentland Hills, Island of Arran, vicinity of Jedburgh.

C. *cancellatus*, Fab. *C. morbillosus*, Leach. Oblong, metallic green or brassy, elytra with three rows of oblong tubercles, and a single smooth elevated line between them. Not unfrequent in decayed wood and under stones. Neighbourhood of Edinburgh; parish of Durness, Sutherland.

C. *hortensis*, Fab. Ovate, thorax black, margined with purple, elytra brassy brown, with three rows of excavated dots. Common near Edinburgh, occurring in gardens, pathways, &c., during spring and summer, and pretty widely spread over Scotland, but much rarer in the northern counties than *C. catenalatus*, and not partaking with that species in the height of its occasional localities. Only one specimen found in Sutherland among many scores of other species of the genus.

C. *violaceus*, Linn. Elongate, black, the margins of the thorax and of the elytra violaceous; elytra dull black, granulated. An elegantly shaped species, not unfrequent in Scotland, in woods and fields, and among garden rubbish. It also occurs among the mountains, and has been taken at Cape Wrath.

C. *glabratus*, Fab. Oblong, entirely black, the elytra very finely granulated, so as to appear smooth and shining. Inhabits the Pentland Hills, but is very scarce in our southern districts. Not unfrequent among the Grampians and other mountain ranges in the north, where it occurs on the summits of the highest hills. Taken at Cape Wrath, and in other parts of Sutherland.

C. *nitens*, Linn. Ovate, head and thorax golden coppery, elytra brilliant green, margined with coppery-red, and having three blackish ribs on each. Under side of the body, and legs, shining black. This, though one of the smallest, is the most richly adorned of the British Carabi, and is one of the most beautiful of coleopterous insects. It is pretty generally spread over the upland and moorish districts of Scotland. We did not find it in

[1] *Species Général*, t. ii. p. 33.

[2] *Règne Animal*, t. iv. p. 412.

Sutherland, but we have specimens from the shires of Mid-Lothian, Lanark, Dumbarton, Argyll, Perth, and Forfar. It is always regarded as a valuable acquisition, on account of its extreme beauty.

C. *clathratus.* Oblong-ovate, of a dark brassy hue, thorax rather square, the posterior angles not much produced, the elytra with three elevated lines, and a triple series of deep golden excavations. This is one of the largest and finest of the British Coleoptera. It has hitherto been regarded as a very rare insect, but a closer examination of the wilder districts will probably bring it into more frequent view. We were the first to take it in Scotland,—which we did many years ago, and in considerable numbers (nine or ten specimens in a few days), in the island of Colonsay, the hospitable habitation of John Macneill, Esq. It has been since taken by Mr Macleay in Caithness. Capt. Graham, R. N. and others, also captured several specimens in different parts of Sutherland (near Invershin, on the point of Tongue, and the vicinity of Lairig), in the month of August 1833; and Mr George Little has collected it for some seasons at Ormsary, on the mainland of Argyllshire. On the continent this beautiful insect is found in Siberia, Sweden, Hungary, Italy, and the south of France, especially in the environs of Montpellier. It varies singularly in regard to the development of the true or membranaceous wings. Those which occur in the south of Europe are large, and furnished with wings; those of Sweden and Siberia are apterous, and of smaller size.

GENUS CALOSOMA,[1] Weber, Fab. First four articles of the anterior tarsi dilated in the males; the first three very strongly, the fourth often more slightly. Terminal article of the palpi very slightly securiform. Antennæ filiform; the third article slightly compressed, sharp on the outer edge, and sensibly longer than the others. Labrum bilobed. Mandibles broad, very slightly curved, more or less sharp, transversely striated, without obvious teeth on their interior. A strong tooth on the middle of the emargination of the mentum. Thorax short, almost transversal, more or less rounded. Elytra usually of a square form, more or less elongated, rarely oval or rounded. Wings most frequently fit for flight.

This genus is very widely distributed. There are about thirty species in all, spread in different proportions over Europe, Asia, Africa, and America. *C. sycophanta* (Plate CCXXXV. fig. 2) and *inquisitor* have occurred in Britain. The genus is as yet unknown in Scotland.

3*d*, The third and last division of the *Grandipalpi* of Latreille presents an assemblage of characters which clearly distinguish its component parts from those of the two preceding. Most of the species are winged. The anterior tarsi of the males are always dilated. The labrum is entire. The exterior palpi are merely somewhat dilated or thicker at the extremity, the last joint being in the form of a reversed and elongated cone. The internal side of the mandibles presents no tooth deserving of notice; the one in the middle of the emargination of the mentum is bifid. The centre of the superior margin of the ligula is elevated to a point. On the internal side of the anterior tibiæ of several there is a short emargination, or one of the two spurs is inserted higher than the other, so that in this respect these *Carabici* are somewhat ambiguous, and might be placed, as well as those of the ensuing section, immediately after the *Patellimani.* They usually inhabit moist situations. A few, such as *Omophron,* seem to connect their tribe with that which follows,—the aquatic Carnivora.

In some in which the body is flattened, or convex and suborbicular, the eyes are of ordinary size; the antennæ linear, and generally consisting of elongated and almost cylindrical joints; the external sides of the maxillæ are bearded, and the two internal spines of the two anterior tibiæ are on a level at their origin; these tibiæ have merely a simple longitudinal canal. In LEISTUS, Frœhlich (*Pogonophorus,* Lat.), the exterior palpi are much elongated, the mandibles are dilated at their base, the head is suddenly narrowed behind the eyes, and the antennæ are long and slender. All the species belong to Europe, and the greater proportion are found to occur in Britain. NEBRIA, Lat. resembles *Leistus,* but the palpi are much shorter, the mandibles not dilated, the head not restricted, and the antennæ proportionally thicker, and composed of shorter articulations. Several of the species, such as *N. Gyllenhalii, brevicollis,* &c., are classed by English entomologists in the genus *Helobia* of Leach. In OMOPHRON of Lat. (Plate CCXXXIV. fig. 18), the first joint only of the two anterior tarsi is dilated in the males.

In other genera the body is tolerably thick, and the eyes large and prominent; the antennæ are slightly enlarged near the extremity, and composed of short joints, mostly in the form of a top or reversed cone; one of the two spines of the internal extremity of the two anterior tibiæ is inserted higher than the other, with a notch between them. The four or first three joints of the anterior tarsi of the males are in general but slightly dilated. The palpi are more elongated. They occur chiefly by the sides of rivers in Europe and in Siberia. We may here place the genus ELAPHRUS,[2] in which the thorax is convex, rounded, narrowed posteriorly, and nearly of the same length as the head. The elytra are convex and almost parallel. This genus was separated with great propriety by Fabricius from Cicindela of Linn. It is constituted by a few small species, generally distinguished by metallic lustre, and of which one of the most beautiful, *E. lapponicus,* was lately presented to us by Professor Lyell, the learned author of the *Principles of Geology.* It has been hitherto only known as a native of Lapland, and was discovered by Mr Lyell on the north-west side of Catlaw, a mountain in Forfarshire, on a spot nearly 2000 feet above the level of the sea. Several of the smaller species which formerly belonged to *Elaphrus* now form the genus *Notiophilus* of Dumeril. Such are *N. aquaticus, biguttatus,* &c.

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[1] Καλος, *beautiful,* and σωμα, *body.*

[2] Fabricius derives the name from Ελος, *a marsh.* We think it may be more plausibly traced to Ελαφρος, *light, active.*

Synoptical Table of the preceding Section, according to the System of Dejean.

SIMPLICIPEDES.

- Elytra carinated on the sides, and embracing a part of the abdomen. Lateral edges of the thorax
  - scarcely or not at all elevated, and not produced. Anterior tarsi
    - alike in both sexes.......... 1. *Cychrus.*
    - dilated in the males.......... 2. *Sphæroderus.*
  - much elevated, and produced behind.......... 3. *Scaphinotus.*
- Elytra not carinated on the sides, and not embracing the abdomen. Upper lip
  - with two or three lobes. The tooth in the notch of the mentum
    - wanting.......... 4. *Pamborus.*
    - simple. Anterior tarsi
      - not dilated in the males.......... 5. *Procerus.*
      - dilated in the males. Upper lip
        - trilobed.......... 7. *Procrustes.*
        - bilobed. Third joint of the antennæ
          - cylindric, and scarcely longer than the others.......... 8. *Carabus.*
          - compressed, sharp exteriorly, and sensibly longer than the others.......... 9. *Calosoma.*
  - entire. The tooth in the notch of the mentum
    - wanting.......... 11. *Pteroloma.*
    - simple.......... 5. *Tefflus.*
    - bifid. Last joint of the palpi
      - scarcely or not at all securiform. Antennæ
        - nodose and elongate. Anterior tarsi dilated in the males,
          - in the three first joints,
            - nearly in a square form, more or less elongate.......... 10. *Leistus.*
            - triangular or heart-shaped.......... 12. *Nebria.*
          - in the first joint only.......... 13. *Omophron.*
        - short and rather thick. Last joint of the palpi
          - elongate and obconic. Anterior tarsi dilated in the males,
            - in the three first joints.......... 14. *Pelophila.*
            - in the four first joints. Thorax
              - quadrate, and wider than the head.......... 15. *Blethisa.*
              - rounded, and of the same width as the head.......... 16. *Elaphrus.*
          - short, and somewhat inflated.......... 17. *Notiophilus.*
      - rather strongly securiform.......... 18. *Metrius.*

B.

SECTION 7TH, SUBULIPALPI, Lat. Dejean.

These form of themselves the second general division of the Carabici, and are distinguished from the preceding sections by the form of the exterior palpi, of which the penultimate obconical joint is united to the following, forming with it a common oval or fusiform body, terminated either gradually or suddenly in a point, or in the manner of an awl. The two anterior tibiæ have always an emargination on the inner side. The first two articles of the anterior tarsi are alone dilated in the males. This division contains only three genera, as follows:

Last article of the palpi
- at least as large as the preceding. Penultimate article of the maxillary palpi
  - as large as the last....1. *Trechus.*
  - smaller than the last..2. *Lachnophorus.*
- much shorter than the preceding..3. *Bembidium.*

Of the two great tribes, viz. CICINDELETÆ and CARABICI, with the principal genera of which we have just been engaged, there are 2494 species enumerated in the last edition of the Catalogue of Comte Dejean. We come now to

TRIBE 3D, HYDROCANTHARI, Lat.

This tribe is composed of the undivided genera *Dytiscus* and *Gyrinus* of the old writers. Their feet are adapted for swimming; the last four being compressed, ciliated or laminiform, and the last two at a distance from each other. The mandibles are almost entirely covered. The body is always oval, the eyes but slightly prominent, and the thorax much wider than long. The terminal hook of the maxillæ is curved from its base; those at the extremity of the tarsi are often unequal.

All these aquatic Coleoptera pass both their first and final stage of existence in the fresh and placid waters of lakes and marshes, or the undisturbed parts of tranquil rivers, and are distributed over all the countries of the earth, wherever such localities occur, from Greenland to Van Diemen's Land.

The old genus *Dytiscus* (Pl. CCXXXV. fig. 3 and 4) embraced a vast assemblage of aquatic insects which the more minute observance of modern times has partitioned into many genera. They form a truly amphibious family; for although water is their favourite element, they survive for a long time on moist land, and most of them fly about in the evening and morning twilight, and even during the darkness of the dewy night, with great power and celerity. They vary considerably in size, according to the species, some being extremely small, while others measure between one and two inches in length. They are fierce and voracious in their habits, preying indiscriminately upon whatever smaller and softer tribes they are able to subdue. They are frequently observed resting on the surface of the water, with their legs expanded, their heads downwards, and the terminal segment of their bodies in contact with the air. It is thus that they carry on the process of breathing, for they cannot respire except by bringing a globule of atmospheric air in contact with the stigmata, which are placed on the sides of the abdomen, just beneath the outer margins of the elytra. Being specifically lighter than water, when they feel the necessity of respiration they have nothing to do but to allow themselves to float to the surface, where, by a peculiar action of the tips of the elytra and the terminal segment of the body, a portion of air is brought into contact with the stigmatic openings. The bodies of the larvæ of these insects (Pl. CCXXXV. fig. 6) consist of eleven well-defined segments. The head is large, flattish, covered above by a scale or shield marked down the centre by a longitudinal furrow. On each side there are five or six black tubercles which are regarded as eyes, and anterior to the eyes are placed the antennæ, consisting of three articulations. The mouth is armed with a pair of strong, horny, curved, sharp-pointed mandibles, which serve to seize and transfix the prey. According to Swammerdam and Degeer, these organs are pierced so as to act as suckers, by means of which the animal juices are absorbed. Near the extremity of the abdomen two delicate appendices may be perceived, pointing obliquely downwards. By means of these the larva appears to suspend itself occasionally from the surface of the water when it wishes to respire. The principal stigmatic openings are at the end of the abdomen, and consist of two small cylindrical bodies, which, when the creature floats, come in contact with the air, and communicate with the tracheal vessels, which are seen to traverse beneath the skin on either side of the body. The movements of these insects in the larva state are effected in the water, partly by the legs and partly by an undulatory motion of the tail. They prey upon other larvæ, such as those of dragon-flies, ephemeræ, gnats, &c. As an instance of their great voracity, it may be mentioned that we once observed one of the larger kinds transfix and suck out the juices of thirteen well-grown tadpoles in a single day. When the period of their transformation has arrived, they leave the water and bury themselves in the moist soft earth of a neighbouring bank. There they work for themselves an egg-shaped chamber, in which they assume the nympha state. (Pl. CCXXXV. fig. 9.) How long they remain in that condition is not very precisely known, from the difficulty of rearing them in confinement throughout their entire changes, but it is believed that the insect is not long of making its appearance in the perfect state. It may then be kept alive in a tumbler for several seasons, and the larger kinds (*Dytisci* proper) soon assume a certain degree of tameness and familiarity, will follow the finger around the walls of their transparent prison, and, coming to the surface at an accustomed signal, will demand, according to their own mode of expression, a young earthworm, or a piece of fresh beef or mutton; for on these and several other articles they feed from the first with extreme, and as it were accustomed greediness.[1] They may thus be said to be aquatic in the larva state, terrestrial in that of nymph, and amphibious in their winged condition.

GENUS DYTISCUS,[2] Linn. Antennæ setaceous, longer than the head. External palpi filiform, or a little enlarged towards their extremity. Anterior tarsi patelliform in the males, the middle pair with their basal joints dilated; the hind pair long, thick, and tapering to the apex, where there are two very small claws. Pl. CCXXXV. fig. 3 and 4.[3]

The Dytisci are large aquatic beetles, the characteristic habits of which have been sketched in our preceding

[1] Esper kept a living specimen of *Dytiscus marginalis* in a glass vessel for three years and a half. It fed on beef.

[2] From δυτης, *a diver.*

[3] Figure 5 of the plate above referred to represents the head of *D. serricornis*, a species remarkable for the anomalous form of the antennæ. (See *Nov. Act. Acad. Scient. Stockh.* xx. 1, 3.)

general observations. We are acquainted with about fourteen species, six or seven of which inhabit Britain.

D. *punctulatus* seems to be the most common in Scotland. It thrives well in confinement, and will live for a year or two in any small vessel, feeding on earthworms and shreds of beef or mutton.[1] *D. marginalis*, when recently captured, has a smell resembling liquorice. It is said to kill Hydrous piceus, which is a much larger and apparently stronger insect, by piercing it between the head and thorax, the only part of the body which is unprotected. Esper asserts that it is much affected by atmospheric changes, and that it indicates these, when in a state of confinement, by the height at which it remains in its jar.

In the genus Colymbetes[2] of Clairville (fore leg, Plate CCXXXV. fig. 7), the four anterior tarsi have their three first joints equally dilated in the males, and forming collectively a small pallet in the form of a lengthened square. The antennæ are at least as long as the head and thorax. The eyes are slightly or not at all projecting. Many of these insects are common in ditches and small brooks, and their habits resemble those of the preceding genus. There are about seventy species in all, of which one half inhabit Britain.

The genus Acilius was first proposed by Dr Leach in the *Zoological Miscellany*. It is distinguished by the great flatness of the species; by the hairy elytra of the females, which have but few striæ; and by the basal joint of the tarsi in the second pair of legs not being dilated.

In the genus Hygrobia[3] of Lat. the antennæ are shorter than the head and thorax, the body is ovoid, and very thick in the middle, and the eyes are prominent. (Plate CCXXXV. fig 11.)

In Hydroporus[4] of Clairville, the four anterior tarsi are nearly similar, and spongy underneath, in both sexes, and are composed apparently of only four joints, the fifth being deficient, or very small, and concealed along with a portion of the fourth in a cleft of the third articulation. The scutellum is not apparent.[5] In Noterus[6] of the same author, the antennæ are slightly dilated in the middle, and the last joint of the labial palpi is emarginate, and appears forked. In Haliplus,[7] Lat. there are only ten distinct joints in the antennæ; the external palpi are fusiform, or have a more slender termination, tapering to a point; the body is convex and ovoid beneath; all the tarsi are filiform, composed of five cylindrical joints, and have nearly the same form in both sexes.

All the preceding genera of *Hydrocanthari* belonged to the old genus *Dytiscus*. The remainder of the tribe are comprised in the

Genus Gyrinus,[8] Linn. Antennæ shorter than the head, the basal joint very large, and produced externally into a triangular ciliated lobe, the rest forming a clavate mass, attached by a short peduncle to the upper side of the first joint. Anterior legs rather long, and projecting like arms; the others compressed, ciliated, and formed for swimming. (Plate CCXXXV. figs. 8 and 12.)

In this genus the body is oval and generally very glossy. The head is sunk in the thorax almost to the eyes, and these are large, and divided by a horny process or border, in such a way that there seems to be two above and two below. Only seven joints of the terminal portion of the antennæ are distinctly visible. The singular auriform shape of these organs induced Latreille to form the Gyrini into a family along with *Parnus*, under the name of *Otiophori*. But at an after period that great entomologist approximated the genus to the *Dytiscidæ*, thereby correcting the error he had previously committed of confounding, as Mr Macleay observes, a relation of analogy with one of affinity. The Gyrinidæ live in society, and several species are extremely common on our ponds, and ditches by the way side. They swim flat upon the surface, with their shining backs above water, chasing each other in circles, or darting about in more irregular gyrations. When hemmed into a corner of the pond, they make their escape by darting beneath the surface, carrying along with them a portion of air, which shines like quicksilver. Britain produces several species of this genus. They are known in England by the name of whirlgigs. These insects fly well, and transport themselves with ease and rapidity from place to place. The females deposit their eggs on the leaves of aquatic plants. The eggs are very small, lengthened in the form of little cylinders, and of a white colour tinged with yellow. According to the observations of Degeer, they produced minute six-footed larvæ in the course of eight days, which swam in the water, or crept along the sides of the vessel in which they had been deposited. Neither he nor Roesel, however, could succeed in rearing them to a state of completion. These larvæ (Pl. CCXXXV. fig. 17) exhibit rather a singular aspect, and at first sight resemble small Scolopendræ. They are of a dingy white or greyish colour, and their clear transparent skin permits the view of their internal structure. Their bodies are long, slender, cylindrical, and divided into thirteen rings, which are deeply incised. The head is oval, very much elongated, and flattened both above and below. It is armed in front with a pair of comparatively large curved jaws, tipped with brown, which, when closed, meet with their points in advance of the head, but are capable of wide extension. The structure of these parts demonstrates a carnivorous disposition. The antennæ are very delicate, divided into four articulations, and equal the head in length. The first segment of the body is nearly twice as long as the others, and the three pairs of feet are attached to the first three segments. The eight following rings are garnished with very singular, long, slender, transparent filaments, which float in the water without being apparently under the guidance of the animal. From their resemblance to the gills of the Phryganeæ and Ephemeræ, it is probable that these are the respiratory organs. The twelfth or penultimate segment of the body is furnished with four of these filaments, of much greater length than the preceding, and covered with long hairs or secondary filaments. The last segment, which is much less than the others, is terminated by four long and remarkable hooks, placed parallel to each other, with their points bent beneath inwards. The whole body seems filled with little globules of air, which are in frequent motion, sometimes towards the head and sometimes towards the other extremity. Modeer has described the transformations of these creatures in the Memoirs of the Royal Academy of Sweden. About the beginning of August, according to that author, the larvæ leave the water, and, crawling up the stems of reeds or other aquatic plants, they are transformed into nymphs, beneath the envelope of a small cocoon, pointed at both ends, and formed of a substance resembling grey paper. Towards the end of the same month the perfect insect is

[1] *Entomologia Edinensis*, p. 127.

[2] From κολυμβαω, *to swim.*

[3] From ὑγρὸς, *moist*, and βιος, *life.*

[4] From ὕδωρ, *water*, and πορος, *a passage.*

[5] For the other genera, see the works of Messrs Stephens and Curtis. The Scotch species are described by Messrs Wilson and Duncan in the *Entomologia Edinensis.*

[6] From νοτερος, *humid.*

[7] From ἅλς, *the sea*, and πλοος, *sailing.*

[8] From γυρεω, *to go in a circle.*

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excluded, and immediately jumps into the water. Modeer adds, that the cocoons are very frequently found pierced by the ovipositor of an ichneumon fly.

Great Britain produces nine species of the genus *Gyrinus* (including *G. villosus*, which belongs to *Potamobius*, Leach[1]). There are twenty-six in all. They are rare in Africa and Asia, but are widely spread over Europe, North and South America, and New Holland. We have received a large species from Java. They are also found at the Cape and the Isle of France.

The most common and best-known species in this country is *G. natator*, of an oval form, bluish-black, extremely glossy, the inflected margin of the elytra, apical segments of the abdomen, and legs, ferruginous. This agile little creature appears to have been rather a favourite object of observation with the entomologist. "Water, quiet still water," says Mr Knapp, "affords a place of action to a very amusing little fellow (*Gyrinus natator*), which, about the month of April, if the weather be tolerably mild, we see gamboling upon the surface of the sheltered pool; and every schoolboy who has angled for minnows in the brook is well acquainted with the merry swimmer in his shining black jacket. Retiring in the autumn, and reposing all the winter in the mud at the bottom of the pond, it awakens in the spring, rises to the surface, and commences its sports. They associate in small parties of ten or a dozen near the bank, where some little projection forms a bay, or renders the water particularly tranquil; and here they will circle round each other, without contention, each in his sphere, and with no apparent object, from morning until night, with great sprightliness and animation; and so lightly do they move on the fluid, as to form only some faint and transient circles on its surface. Very fond of society, we seldom see them alone, or, if parted by accident, they soon rejoin their busy companions. One pool commonly affords space for the amusement of several parties, yet they do not unite or contend, but perform their cheerful circlings in separate family associations. If we interfere with their merriment they seem greatly alarmed, disperse or dive to the bottom, where their fears shortly subside, as we soon again see our little merry friends gamboling as before. This plain, tiny, gliding water-flea seems a very unlikely creature to arrest our young attention; but the boy with his angle has not often much to engage his notice; and the social active parties of this nimble swimmer, presenting themselves at these periods of vacancy, become insensibly familiar to his sight, and by many of us are not observed in after-life without recalling former hours—scenes of perhaps less anxious days; for trifles like these, by reason of some association, are often remembered when things of greater moment pass off and leave no trace upon the mind."[2] Wordsworth has likened a beetle to

A mailed angel on a battle day;

and Messrs Kirby and Spence describe the subjects of our present notice as being "covered with lucid armour,—when the sun shines they look like little dancing masses of silver and brilliant pearl."[3] They however exhale a disagreeable and rancid odour.[4]

FAMILY II.—BRACHELYTRA, Lat.[5]

In this, the second family of Pentamerous Coleoptera, Latreille places those genera which have only a single palpus to each maxilla, or four in all, including the labial pair. The antennæ, sometimes of equal thickness, and at others slightly enlarged at the extremity, are usually composed of lenticular or graniform articulations; the elytra are much shorter than the body (from which circumstance they derive their name), and the latter is narrow, elongated, generally depressed, with the coxæ of the two anterior legs very large. The posterior extremity of the body is provided with two vesicles, which are protruded at will.

These Coleoptera composed the great genus *Staphylinus* (of Linnæus) before its subdivision by more recent writers. Ancient authors appear to have bestowed the name of *Staphylinus* on certain species, which, from the characters assigned them, and their reputed injurious effects on horses, we can scarcely refer to any of the modern genera of brachelytrous insects. Mouffet, however, having satisfied himself that some ancient passage did apply with sufficient correctness, made use of the term Staphylinus in relation to the present group; and whatever may have been its original application, its meaning is now no longer ambiguous in the modern systems. The genus, as constituted by Linnæus, was first dismembered by Fabricius of two of its component groups, under the generic names of *Pæderus* and *Oxyporus;* and in still more recent times numerous other subdivisions have taken place, which have raised the original genus to the rank of an ordinal section or comprehensive family.

Some writers regard the Staphylini as forming the passage from the Coleoptera in general to the Forficulæ or ear-wigs, which compose the first genus of the *orthopterous* order. In their habits they somewhat resemble the Silphæ and Necrophori. They have usually a large, flattened head, strong mandibles, short antennæ, and a thorax as wide as the abdomen, which is long, narrow and generally depressed. The elytra are very short and truncated, although they still suffice to cover the long membranous wings, which, when not in use, are compactly folded. The upper portion of the segments of the abdomen, being exposed in consequence of the shortness of the elytra, is, contrary to the usual rule among the coleopterous tribes, of as firm a consistence as that beneath. From the terminal segment of the abdomen two vesicles are protruded or retracted at the pleasure of the animal, and from these, when irritated, a subtile vapour makes its escape with a strong odour of sulphuric ether. "Though most of the micropterous species," Mr Kirby observes, "have a fetid smell, yet there are some exceptions to this amongst them. One species (*S. suaveolens*, K. MS.), related to *S. micans*, Grav. which I once took, smelt precisely like a fine high-scented ripe pear; another, *Oxytelus morsitans*, like the water-lily; a third, *O. rugosus*, like water-cresses; and lastly, a fourth (*S. fuscipes*) like saffron." M. Leon Dufour has described the apparatus by which these odours are produced.[6] The insects of this family, when attacked or touched, elevate the extremity of their abdomen, bend it in various directions, and frequently protrude the vesicles above alluded to. They also use the point of the abdomen to close or unfold their wings. The tarsi of the two anterior legs are frequently broad and dilated, and their coxæ, as well as those of the intermediate pair, are very large. The species usually occur in damp places, under stones, in earth, and excrementitious matters. Some live in mushrooms and fungi, or in

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1 *Orectochilus* of Eschscholtz and Dejean. 2 *Journal of a Naturalist*, p. 307. 3 *Introduc. to Ent.* vol. ii. p. 372.
4 For the Scottish species, see *Entomologia Edinensis*, p. 130.
5 From βραχὺς, *short*, and ἔλυτρον, *sheath*. Microptera, Gravenhorst. Staphylinus, Linn.
6 *Ann. des Sciences Nat.* t. viii. p. 16.

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rotten wood, while a few of the smaller species are found on flowers. They are all swift, active, and voracious.

The larvæ bear a close resemblance to the perfect insect. In figure they more nearly resemble an elongated cone, the base of which is formed by the head; the terminal segment is prolonged into a tube, and is accompanied by two conical and hairy appendages. Their food and habits of life are very similar to those of the imago.

According to M. Dufour, the only essential difference between the alimentary canal of the brachelytrous tribes and that of the carnivorous Coleoptera consists in the absence of the crop. The first stomach is small and destitute of folds; the second is very long and pilose; the intestine is extremely short. The biliary vessels are inserted at the same lateral point as in the Carnivora, and present in some species, near the middle, a knot or vesicle, not observable in any other insects. Their sexual apparatus differs greatly from that of the carnivorous Coleoptera.[1]

Many of the species of this family are of minute dimensions, and a knowledge of their names and characters is of difficult attainment. Many more of the described species than have been hitherto collected no doubt exist in Britain, and many of the Scandinavian species will probably be discovered to inhabit Scotland. There is every reason, indeed, to believe that an assiduous entomologist would here reap a rich harvest among a tribe of insects which seem characteristic of, though by no means peculiar to, temperate or northern countries. Notwithstanding the obscurity in which many of our smaller species are still involved, Great Britain already possesses nearly *eight hundred* recorded species of brachelytrous insects, while the last edition of Dejean's Catalogue (1833), including European and exotic kinds, gives only 789.[2]

In a family so extensive, and of late so minutely subdivided, we must satisfy ourselves with a few brief indications of the principal genera. It is divided into five great sections.

1*st*, Fissilabra.

In these the head is completely exposed, and separated from the thorax (which is sometimes square or semi-oval, sometimes rounded or cordiform, and truncated) by a neck or sensible restriction. The labrum is deeply bilobed.

In Oxyporus,[3] Fab. (Pl. CCXXXV. fig. 13), the maxillary palpi are filiform, those of the labium terminated by a large and lunate article. The antennæ are large, perfoliate, and compressed. The anterior tarsi, of which the last (and next to it the second) joint is the longest, are not dilated. The species inhabit *Boleti* and *Agarici*. In Astrapæus, Grav. the four palpi are terminated by a larger and nearly triangular article. The anterior tarsi are greatly dilated, and the first and last joints are the longest. In Staphylinus, Fab. (the true *Staphylini*), all the palpi are filiform, and the antennæ are inserted between the eyes, above the labrum and mandibles. Some, particularly the males, have the anterior tarsi greatly dilated, and the antennæ rather distant at the base; the length of the first joint being equal at most to that of a fourth of the whole number. The head is but slightly elongated. These, according to the views of some authors, alone constitute the genus.[4] Our largest British species, *S. Olens* (*Goerius*, Leach), is placed here by Latreille, along with a more ornamental example, *S. erythropterus* (Pl. CCXXXV. fig. 16). Others are linear, with the head and thorax in the form of an elongated square, and the antennæ approximated at the base, and strongly geniculate and granose. The anterior tarsi are either not at all or but slightly dilated. The anterior tibiæ are spinous, with a stout spine at the extremity. The labrum is small. These form the genus *Xantholinus* of some authors. In Pinophilus of Grav. the palpi are filiform, but the antennæ are inserted before the eyes, outside the labrum, and near the exterior base of the mandibles. In Lathrobium (Pl. CCXXXV. fig. 21) of the same author (*Pæderus*, Fab.), the palpi are terminated suddenly by a pointed and often indistinct article, much smaller than the preceding; those of the maxillæ are longer than the labial; the antennæ are inserted as in *Pinophilus*; the anterior tarsi are strongly dilated in both sexes; and the length of the last joint of the four posterior tarsi is almost equal to that of the four preceding taken together.

2*d*, Longipalpi.

In this section the head is also completely exposed, but the labrum is entire, the maxillary palpi nearly as long as the head, with a clavate termination formed by the third joint, the fourth concealed or but slightly visible, and, when apparent, terminating the club in the form of a small point; the preceding much enlarged. These insects dwell chiefly along the shores of rivers, or on banks in the vicinity of water.

In Pæderus, Fab. (Pl. CCXXXV. fig. 15), the antennæ, inserted before the eyes, are filiform, or gradually increase in thickness. In Evæsthetus of Grav. the antennæ are likewise inserted before the eyes, but are hardly longer than the head, and almost entirely moniliform; the body is but slightly elongated, and the head as wide as the thorax. In Stenus,[5] of Lat. (Pl. CCXXXV. fig. 20), the antennæ are inserted near the margin of the eyes, and are terminated by a triarticulated club. The extremity of the mandibles is forked. The eyes are large.

3*d*, Denticrura, Lat.

This section differs from the preceding in the form of the maxillary palpi, which are much shorter than the head, and always consist of four distinct articles; the anterior tibiæ, at least, are dentated or spinous along their exterior side. The last joint of the tarsi, which in most are bent under the tibiæ, is as long as all the preceding joints combined, or longer; and the first or first two are usually so small or so concealed that their total number does not seem to exceed two or three. In several males the forepart of the head, and even the thorax, is armed with horns. The antennæ are inserted before the eyes. With the exception of the *Tachini*, the anterior tarsi are no longer dilated.

In Oxytelus, Grav. the palpi have an awl-like termination, the antennæ are mostly granose, and gradually enlarged towards the extremity. The tarsi present only

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[1] *Ann. des Sciences Nat.*; and *Règne Animal*, p. 432.

[2] Mr Stephens arranges his British *Brachelytra* in five families, containing eighty-two genera. How vague, from its extremely comprehensive limits, must have been the original *genus* Staphylinus of Linn., when even our indigenous species present the groundwork of such diversified groups! Perhaps, however, we may be now falling into the opposite extreme.

[3] From ὀξύπορος, *that crosses swiftly*.

[4] *S. dilatatus*, Fab. has been separated from the above on account of its antennæ, which form an elongated serrated club. It is said to feed on caterpillars, which it searches for on trees.

[5] From στενος, *narrow*.

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three distinct articles. In OZORIUS, Leach, the body is cylindrical, all the tibiæ broadened and dentated, the head as long as it is wide, the thorax almost cordiform. The mentum is large and buckler-shaped. The species come from America and Madagascar. In COPROPHILUS,[1] Lat., the body is flattened, and the antennæ much longer than the head.

4*th*, DEPRESSA, Lat.

In these the head is disengaged or free, as in the preceding, the labrum entire, the maxillary palpi short, and of four articulations; but the tibiæ are simple, or without teeth or exterior spines, and the tarsi exhibit five obvious articulations.

In the two following genera the palpi are filiform. OMALIUM, Grav. Thorax as wide as the elytra, wider than the head, and almost forming a transverse square; the angles, at least the anterior ones, rounded, and frequently exhibiting a raised lateral margin; the antennæ enlarging towards their extremity. LESTEVA, Lat., *Anthophagus*, Grav. (Pl. CCXXXV. fig. 22.) Thorax cordiform, narrowed, truncated posteriorly, almost isometrical, as wide as the head, and narrower than the elytra. In the ensuing genera the palpi are subulate. MICROPEPLUS,[2] Lat. (Pl. CCXXXV. figs. 10 and 14.) Antennæ terminating in a solid club, and lodged in fossulæ of the thorax. PROTEINUS, Lat. Antennæ granose, somewhat perfoliate, and larger at the end, but clavate, always exposed, and inserted before the eyes; the thorax is short, and the elytra cover the whole of the abdomen. ALEOCHARA, Grav. Antennæ inserted between the eyes, or near their inferior margin, and exposed at the base, with the first three joints obviously longer than the following ones, which are perfoliate, the last elongated and conical; the thorax is nearly oval, or like a square rounded at the angles.

5*th*, MICROCEPHALA, Lat.

Head sunk posteriorly into the thorax, nearly up to the eyes, and separated neither by a neck nor visible restriction; the thorax is in the form of a trapezium, and is widened from before backwards. The body is less elongated than in the preceding section, and approaches more to an ellipsis; the head is much narrower, contracted, and projecting forwards, and the mandibles are of moderate size, edentated, and simply curved at the point. The elytra in several cover rather more than the half of the upper surface of the abdomen. Some of the species live on flowers and mushrooms, others on dung.

In LOMECHUSA, Lat., the tibiæ have no spines; the antennæ from the fourth joint form a perfoliaceous club, elongated or fusiform; the palpi are subulate; the antennæ frequently shorter than the head and thorax. In TACHINUS,[3] Grav. (Pl. CCXXXV. fig. 23), the tibiæ are spinous, the antennæ composed of pyriform joints, and insensibly enlarging; the palpi are filiform. TACHYPORUS[4] of Grav. (Pl. CCXXXV. fig. 28) resembles the preceding in the tibiæ and antennæ; but the termination of the palpi is subulate.[5]

FAMILY III.—SERRICORNES, LAT.

In this family of pentamerous Coleoptera, we find only four palpi, as in the preceding family, and those that follow. The elytra cover the abdomen, which character, with certain others, distinguishes the SERRICORNES from the BRACHELYTRA.[6] The antennæ, with some exceptions, are equal throughout, or smaller at the extremity, dentated either like a saw or comb, or even fan-like; and in that respect are more developed in the males. The terminal article of the tarsi is often bilobed or bifid. These characters are rarely visible in the ensuing family, that of CLAVICORNES; at which, however, we shall arrive by transition so graduated, that rigorous limits are with difficulty assigned.

SECTION 1ST, STERNOXI,[7] Lat.

Body always of a firm and solid consistence, and generally of an oval or elliptical form; the feet in part contractile; the head sunk vertically into the thorax up to the eyes; and the præsternum or median portion of the thorax elongated, dilated, or advanced as far as beneath the mouth, and usually marked on each side by a groove, in which the antennæ, always short, are lodged, and prolonged posteriorly to a point, which is received by a depression of the anterior extremity of the mesosternum. The anterior legs are distant from the anterior extremity of the thorax. This section is further divisible into two tribes.

TRIBE 1ST, BUPRESTIDES.

In these the posterior projection of the præsternum is flattened, not terminated in a laterally compressed point, and simply received into a depression or emargination of the mesosternum. The mandibles are frequently terminated in an entire point, without fissure or emargination. The posterior angles of the thorax are either not at all or but slightly prolonged. The terminal article of the palpi is generally almost cylindrical, scarcely thicker than the preceding; the others globular or ovoid. Most of the articulations of the tarsi are generally broad or dilated, and furnished with pellets beneath. These insects never leap, a character which distinguishes them decidedly from the *Elaterides*. This tribe corresponds to the old *genus Buprestis*, as constituted by Linnæus,—the *Richard* of Geoffroy;[8] so named by the latter author on account of the

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[1] From κοπρος, *dung*, and φιλος, *a lover*.

[2] From μικρος, *small*, and πεπλος, *a covering*; the elytra being so short as to leave a considerable part of the abdomen exposed. This genus is placed in the necrophagous family, *Nitidulidæ*, by Mr Stephens.

[3] From Ταχινος, *swift*, *active*.

[4] From Ταχυς, *quick*, and πορος, *a passage*.

[5] For the species of this family, see Gravenhorst's *Coleoptera Microptera*, Gyllenhal's *Insecta Suecica*, &c. With Mr Duncan's aid, we have described the genera and species of ordinary occurrence near Edinburgh (*Ent. Ed.* pp. 308–388); but, as already mentioned, numerous undescribed *Brachelytra* inhabit Scotland.

[6] In the genus *Atractocerus*, however, the elytra are extremely short. In Proteinus of the preceding family they are, on the other hand, comparatively long; thus showing the tendency to exception in each general rule.

[7] From Στερνον, *sternum*, and οξυς, *pointed*.

[8] "This genus," it has been observed, "furnishes the most beautiful coleopterous insects which can adorn either the domain of nature or the cabinet of the naturalist. Most part of the species are clothed with such brilliant colours, that Geoffroy has thought proper to designate them all under the generic appellation of *Richard*. The origin of this name is as singular as its application is fantastical. It was originally given to the jay, in consequence of the facility with which that bird was taught to pronounce the word." (Griffith's *Animal Kingdom*, *Insecta*, part 2d, p. 356.) Professor Klug has stated that the Berlin Museum possesses not less than five hundred species of the Linnæan genus Buprestis.

extreme richness of their external covering. Even of the European species several are extremely beautiful, and many of the foreign kinds are not only of the largest size for the class of insects, but present a brilliant surface, beset as it were with gold and emeralds, or glittering with an iridescent play of green and azure. The body is in general oval, somewhat lengthened, rather wider and obtuse before, as if truncated, and narrowed behind from the base of the abdomen. The eyes are oval, the thorax short and wide. The scutellum small or unapparent. The extremity of the elytra is frequently dentated. The legs are short.

All these insects walk very slowly, but fly exceedingly well in dry and sultry weather. When an attempt is made to seize them they drop upon the ground, with a view no doubt to conceal themselves in the subjacent herbage. The abdomen of the female is furnished at its extremity with a coriaceous or horny conical appendage, composed of three pieces (the terminal abdominal rings), and which may be regarded as a kind of ovipositor, by which she deposits her eggs in dry or decayed wood, in which the larvæ dwell. Several of the minor species occur on leaves and flowers; but the greater proportion are found in forests or depots of timber. They sometimes appear suddenly in places where they were never seen before, having been involuntarily transported in foreign timber in the nymph or larva state.

The *Buprestides* are very common in South America and many of the other sultry regions of the earth. They decrease in number as we advance northwards into the temperate climes, and altogether disappear in colder countries. Scarcely a score occur in Britain; and of these we are not aware that even one has yet been found in Scotland.

Genus Buprestis,[1] Lin. Palpi filiform, or slightly enlarged towards the extremity, terminated by an almost cylindrical article. Antennæ of equal thickness throughout, and serrated from the third or fourth joint. Penultimate article of the tarsi deeply notched. Maxillæ bilobed.

These are the characters of the genus Buprestis, as restricted in recent times. Some of the species have no apparent scutellum. Such is *B. fasciculata,* a species from the Cape of Good Hope. It is about an inch long, of a golden or coppery-green, densely punctured, and with little tufts of yellowish or reddish hairs. It sometimes hangs in such abundance on a shrub, as to make it appear all laden with flowers. Others are furnished with a scutellum. Of these we may name *B. gigas* from Cayenne, a species, as its name implies, of the largest size; the thorax cupreous, mingled with brilliant green, and two large spots like burnished steel; the elytra tridentate at the end, cupreous in the centre, bronze-green on the margin, with impressed points and some elevated lines and ridges. Its larva is represented on Pl. CCXXXV. fig. 19. On the same plate (fig. 18) we have delineated a magnificent species, *B. bicolor,* lately received from Java. It is of a deep-green colour, with a golden lustre, two cream-coloured spots on the elytra, and one on each side of the thorax. It belongs to the genus Catoxantha of Dejean.

Of the other genera of the tribe we shall here name only Trachys, Fab. (Pl. CCXXXV. fig. 26), Aphanisticus, Lat., and Melasis, Oliv.[2] The last-mentioned genus (probably named from *μελας, black*), conducts naturally to

Tribe 2d, Elaterides.

This numerous tribe corresponds to the undivided genus *Elater* of Linnæus, and differs from the *Buprestides* chiefly in the posterior style of the præsternum, which is prolonged to a sharpish point or spine laterally compressed. On examining the living species, the use of the last-named organ becomes obvious. The legs are very short, and when the creature falls upon its back, which it frequently does while dropping from a plant to the ground, it can only assume its natural position by springing upwards, which it is enabled to do by bringing the projecting point into sudden contact with a groove situated in front of the mesosternum. The sides of the præsternum are also distinguished by a groove, in which the antennæ, pectinated or bearded in several males, are partly lodged. The females have a species of elongated ovipositor, with two lateral pieces pointed at the end, between which is the true oviduct. The tarsi are entire.

The Elaterides occur in flowers, on various plants, and on the ground. We owe to Degeer the description of the larva of one species (*undulatus*). It is long, nearly cylindrical, provided with small antennæ, palpi, and six feet. Its body consisted of twelve scaly segments, of which the posterior was covered by a circular plate, furnished with two blunt points curving inwards; underneath was a large fleshy mammilla, which seemed to serve the office of a foot. The larvæ of *Elater striatus* are said to do much injury, by attacking the roots of wheat. The grub known in this country under the name of wire-worm is an Elater in the early state. It lives under ground for several years, feeding on the roots of grain and vegetables. It is partial to land newly broken up, and does great damage in gardens recently converted from pasture-land. In the year 1813, according to Mr Spence, this larva destroyed the greater proportion of the annuals sown in the botanic garden of Hull. In such cases Sir Joseph Banks recommended that slices of potatoes stuck upon skewers should be buried near the seeds, and examined and cleared of the wire-worms from time to time.

M. Leon Dufour has studied the anatomical structure of several species of this family. In the number, length, and mode of insertion of the hepatic conduits, they show a resemblance to the Carabidæ. The digestive canal is seldom more than once and a half the length of the body. Immediately succeeding an œsophagus, so short as to be included within the region of the head, there is a small smooth conical crop, which appears to have escaped the observation of Ramdhor. The chylific ventricle is bilobed in certain species. This tribe is very extensive both in exotic and European species, and is much more prevalent in temperate and even northern countries than the preceding. The *Elaterides* now consist of numerous genera Some of the American species are remarkable for the fine phosphoric light which is observed to emanate from then during the evening twilight, and when the shades of night have fallen upon the forests. One of these had the fortune to be transported to Paris under the form of nymph or larva; and having made its escape into the streets after the assumption of the perfect state, it greatly astonished the inhabitants of the Faubourg St Antoine. Most of the genera are recognisable, in a general way, by their narrow, elongated, and somewhat flattish forms. We have above sixty species in Britain, arranged according to the modern views, under not less than twenty genera.

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[1] From Βους, *an ox,* and πρηστης, *swelling,* in allusion to the supposed injury produced on cattle by an insect anciently named *Buprestis.*

[2] For the species, the reader may consult Olivier, *Coléoptères,* t. ii.; Fabricius, *Systema Eleut.* t. ii.; and Schœnherr's *Synonymia Insectorum.* See also *Règne Animal,* t. iv. p. 446.

Coleoptera Pentamera.

The various groups of the *Elaterides* are referred by Latreille to two principal divisions.

1*st, Antennæ entirely received into the inferior cavities of the thorax.*

In some the antennæ are received on each side into a longitudinal groove, placed directly under the lateral edges of the thorax, and are always filiform, and simply serrated. The joints of the tarsi are always entire, without prolongations, and in the form of a pellet underneath. The thorax is convex or arched, at least on the sides, and dilates towards the posterior angles in the manner of a lobe, pointed or triangular. They approach the *Buprestides*. Here are placed the genera GALBA and EUCNEMIS.

In others the antennæ, sometimes clavate, are received, at least partially, either into the longitudinal grooves of the lateral borders of the præsternum, or into fossettes placed under the posterior angles of the thorax. The tarsi are frequently provided with little pellets, formed by the prolongation of the inferior parts, or the penultimate article is bifid. Here are placed the genus ADOLECERA, Lat. (Pl. CCXXXV. fig. 29), and others.

2*d, Antennæ exterior or exposed.*

In the genus CEROPHYTUM, Lat. (Pl. CCXXXV. fig. 30), the terminal joint of the palpi, especially the maxillary, is much larger than the preceding, and almost securiform. These insects are more particularly distinguished from the following by their tarsi, of which the first four articles are short, triangular, with the penultimate bifid. The antennæ of the males are ramose on the internal side, the base of the third and following articles being prolonged into a widened branch, rounded at the extremity; those of the female are serrated. In the succeeding genera the articles of the tarsi are entire and almost cylindrical. In HEMIRHIPUS, Lat. (Pl. CCXXXV. fig. 31), the mandibles and labrum are exposed, and the antennæ of the male have a flabelliform termination. The species are foreign to Europe. In ELATER properly so called (Pl. CCXXXV. fig. 27), the antennæ of the males are simply serrated. Here we place the fire-fly, or *mouche lumineuse* of the French colonists, which during the night diffuses from its thoracic spots a strong and beautiful light, sufficient to enable one to read the smallest print, particularly if several are placed together in a glass vessel. By means of this natural illumination the women of the country (the species is South American) are said to pursue their work, and ladies even use it as an ornament, placing it among their tresses during their evening promenades.[1] M. de la Cordaire, who has studied the habits of these insects in the living state, informed M. Latreille that the principal reservoir of phosphoric matter is placed below, at the junction of the thorax and abdomen.[2] Mr Curtis had the insect alive in London, and has recorded his observations with his accustomed accuracy.[3] In the genus CTENICERA,[4] Lat. the antennæ of the males are pectinated.[5]

We shall conclude by observing that the name of *wire-worm*, bestowed on several larvæ of Elaters, is more specially applicable to the early state of *Cataphagus lineatus*[6] of Stephens. Its history appears to be given in the *Stockholm Transactions* for 1777, by Mr Bierkander. He calls it the *root-worm*. It measures when full grown about seven lines in length. The body is very narrow, of a yellow colour, hard, shining, and composed of twelve segments, on the last of which are two indented dark-coloured specks. The head is brown, the extremity of the jaws black. The anterior segments have six scaly feet. It is said to remain five years in the larva state, from which it issues as an Elater, the *E. segetis* of Bierk. supposed to be synonymous with the *E. lineatus* of Linn. and the insect above named of Stephens. Great damage is often occasioned by the wire-worm to the turnip crops. An instance is recorded by Messrs Kirby and Spence of a field in which it had destroyed one fourth of the crop, and the owner calculated his loss at L.100. He one year sowed a field thrice with turnips, which were twice wholly, and the third time in great part, cut off by this destructive larva.[7]

SECTION 2D, MALACODERMI.[8]

The insects of this section are distinguished from the *Sternoxi* by their bodies being generally, in whole or in part, of a soft or flexible texture. From this character they derive their name. Their head is likewise inclosed posteriorly in the thorax, or at least covered by it at the base; but the præsternum is not dilated or advanced anteriorly in the manner of a chin-cloth (*mentonnière*, Lat.), nor is it usually terminated posteriorly in a point received into a cavity of the mesosternum.[9] The Malacodermi are divided into five tribes.

TRIBE 1ST, CEBRIONITES.

So named from the genus *Cebrio* of Fabricius, with which all the others are connected. The mandibles terminate in a simple or entire point, the palpi are of equal thickness, or more slender towards the extremity. The body is rounded or convex in some, oval or oblong, but curved above, and inclined anteriorly, in others. The thorax is transversal, broader at the base, with the lateral angles sharp, or even prolonged, in many, in the form of a spine. The antennæ are generally longer than the head and thorax. The legs are not contractile. The habits of these insects are unknown. Many are found on plants, in moist places.

In CEBRIO (proper)[10] of Lat. the præsternum terminates posteriorly in a point, received by a groove of the mesosternum. All the joints of the tarsi are entire and without pellets, and the posterior thighs are not larger than the others. The species peculiar to Europe appear in great numbers after heavy rains. Of the ten species enumerated by Dejean, seven occur in Europe, one in Africa, one in Java, and one in North America. In CALLIRHIPIS, Lat. (Pl. CCXXXV. figs. 32 and 33), the præsternum is not prolonged into a point, the antennæ are closely approximated at the base, inserted on an eminence,

[1] *Règne Animal*, t. iv. p. 445.

[2] *Ibid.* note. See also *Nouvelles Annales du Mus. d'Hist. Nat.* t. ii. p. 66.

[3] *Zoological Journal*, vol. iii. p. 379.

[4] From κτεις, *a comb*, and κεϱας, *a horn*.

[5] For the British genera and species, see the works of Messrs Curtis and Stephens. Such as have been hitherto ascertained to inhabit Scotland are described in *Entomologia Edinensis*, p. 192–9.

[6] From καταφαγω, *I devour*.

[7] The modern genera of Elaterides are far too numerous to admit of being even named in our present article. We refer the reader, in addition to the systematic works of Fabricius, Olivier, and Latreille, to Palisot de Beauvois's *Insectes d'Afrique et d'Amerique*, Dalman's *Analecta Entomologica*, and the beautiful monograph by Count Mannherheim entitled *Eucnemis Insectorum genus*.

[8] From μαλακος, *soft*, and δεϱμα, *skin*.

[9] The *Cebriones* may be said to constitute an exception to this negative character, and thus approximate the Elaterides; but the inferior extremity of the præsternum does not advance under the head.

[10] Aristophanes applies the name Κεϐϱιον to a species of bird.

and from the third joint, in the males, form a large fan. The terminal joint of the palpi is ovoid, that of the tarsi almost as long as the others united, and presenting between its hooks a little silky and linear appendage. We have represented the head of the species (*C. Dejeanii*), which serves as the type of the genus. It occurs in Java. In Rhipicera[1] of Lat. and Kirby[2] (Pl. CCXXXVI. fig. 1), the inferior surface of each of the first four joints of the tarsi presents two membranous and projecting lobes; the last is long. The antennæ are flabelliform in both sexes, and consist of much more than the ordinary number of eleven joints. The articulations are much fewer in those of the females. The genus consists of a few species from North and South America and New Holland. In Dascillus, Lat. (*Atopa* of Fab.), the antennæ are simple in both sexes, the first three joints of the tarsi reversed cordiform, without membranous prolongations; the penultimate is deeply bilobed. *D. cervinus* (Curtis, B. E. V. pl. 216), the only British species, occurs rather plentifully in the alpine districts of Scotland. In the remaining Cebrionites the mandibles are small, and project but little, if at all, beyond the labrum. The body is generally soft, and almost hemispherical or ovoid, and the palpi terminate in a point. The posterior legs of several are fitted for leaping. They live on aquatic plants. Such are Elodes[3] of Lat. (*Cyphon*, Fab. Steph.), of which the hind thighs differ but little in thickness from those of the preceding genus (we have seventeen kinds in Britain), and Scyrtes, Lat. of which the species are leapers, with the posterior thighs very large, and the tibiæ terminated by two strong spurs.

Tribe 2d, Lampyrides.

This tribe is distinguished from the preceding by the enlarged termination of the palpi, at least of those of the maxillæ; by their straight, depressed, but slightly convex body; and by the thorax, sometimes semicircular, sometimes nearly square or trapezoidal, projecting over and almost concealing the head. The mandibles are generally small, and terminate in a slender, arcuated, very acute point, generally entire. The penultimate joint of the tarsi is always bilobate, and the terminal hooks have neither dentations nor appendages. The females of some are apterous, or have but short elytra. When seized, most of these insects press their feet and antennæ close to the body, and remain as motionless as if they were dead. Several curve the abdomen underneath. They correspond to the old genus *Lampyris* of Linn., and include some species remarkable for their phosphorescent or luminous qualities.

1*st*, Antennæ approximated at the base, the head either prolonged anteriorly in the manner of a snout, or for the greater part, or entirely, concealed beneath the thorax. Eyes of the males large and globular. Mouth small.

Here we place the following genera, in all of which the head is exposed:—1*st*, Lycus,[4] Fab. In this the snout is as long as the preceding portion of the head, or longer, and the antennæ serrated. The elytra are generally dilated, either laterally, or at their posterior extremity, the two sexes (particularly of certain African species) differing greatly in that respect; 2*d*, Dictyoptera, Lat. (Pl. CCXXXVI. fig. 2); and, 3*d*, Omalisus,[5] Geoffroy (ibid. fig. 4). The remaining insects of this division are distinguished from the preceding, not only by the want of a snout (it is not apparent even in the last-named genus), by their head, which in the males is almost entirely occupied by the eyes, and much concealed by the square or semicircular thorax—but more particularly by a very remarkable character, either common alike to males or females, or peculiar to the latter sex, viz. the property of phosphorescence. Hence the names of glow-worms, fireflies, &c. bestowed upon the species which form the genus Lampyris properly so called.[6]

In regard to the general history of these insects, we may observe, that the Greeks applied the name of *Lampyris*, and the Latins those of *Noctiluca*, *Luciola*, &c. without any very special reference, to such insects as were observed to shine during the night with a lambent or phosphoric flame. They were long confounded with *Telephorus* and *Malachius* under the genus *Cantharis*. Geoffroy effected their separation from Telephorus, and placed them in the genus *Lycus*, while Linnæus also combined them with that genus and *Pyrochroa*. Fabricius was the first to restrict and define the genus with propriety.[7] The antennæ are short, the articulations cylindrical and compressed. The head is concealed beneath the anterior margin of the thorax, which is semicircular in the indigenous species. The eyes are large. The body rather soft, oblong-oval, much depressed. The abdomen is serrated on its lateral edges. The elytra are coriaceous, and slightly flexible. The legs are compressed and simple. The females are apterous, with the rudiments of elytra at the base of the abdomen. Other characters are minutely detailed by systematic writers, which we need not here enter into. We shall, however, record some observations, both of a general and particular nature, which we were induced to make in consequence of our having kept the common British glow-worm in confinement.[8]

The beautiful light which emanates from this insect constitutes its most interesting and peculiar attribute. If several ancient nations were worshippers of the sun, and regarded "holy light" as a divine effulgence, the offspring of heaven, and the purest of the elements, we need scarcely wonder that in remote times, when natural phenomena were but slightly understood, even the more obscure manifestations of a supposed celestial principle should have excited the wonder and admiration of mankind. We consequently find many exaggerated accounts of the cause and effects of these flying and creeping lights, which, as they do not illustrate the natural history, properly so called, of the insects themselves, we shall leave for the pre-

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[1] From ῥιπις, *a fan*, and κερας, *a horn*.

[2] *Linn. Trans.* vol. xii. pl. 21, 3.

[3] From ἑλος, *a marsh*, the species usually frequenting moist places.

[4] From λυκοῶ, *I destroy*.

[5] Perhaps from ομαλος, *flat*.

[6] The word λαμπυρος occurs in Aristotle, and is derived from λαμπω, *to shine*, and πυρ, *fire*. The genus in its undivided state is very extensive, containing not fewer than sixty species. We observe, however, that in the last edition of Dejean's Catalogue, so many divisions have taken place, that the genus Lampyris, properly so called, is now made to consist of only *nine* species. It is very poorly represented in Britain, and indeed produces but few European examples. If, as Mr Stephens supposes, *L. splendidula* has been erroneously introduced into the British Fauna, then *L. noctiluoa*, Linn., may be regarded as the sole indigenous species. Some Brazilian species, in which the antennæ of the males consist of more than eleven joints, formed like the laminæ of a feather, constitute the genus *Amydetes* of Hoffmansegg. Others, also peculiar to South America, and of which the antennæ consist of only eleven joints, form the genus *Phengodes* of that author. (Illiger's *Mag.* vi. p. 342.)

[7] For representations of the glow-worm (*L. noctiluca*), see Plate CCXXXVI. Fig. 5 is the winged male; fig. 6 the wingless female; fig. 7 the larva; fig. 10 represents a large and remarkable species, the *Lampyris Savignii* of Kirby.

[8] We here in part avail ourselves of what we have already stated in the *Entomologia* [illegible]*nensis*, p. 202–7.

Coleoptera Pentamera.

sent unrecorded. But the actual phenomena are extremely interesting, on account both of their singularity and beauty, and, without the aid of fiction, are well deserving the attention of the poet and philosopher. Huet, bishop of Avranches, an eminent scholar, composed a poem, entitled *Lampyris;* and the masterly genius of Wordsworth, which draws so much that is new and beautiful from the observance of common things, has not failed to immortalize the radiance of the "earth-born star." "And if," say Messrs Kirby and Spence, or one or other of these authors, while speaking of the British glow-worm, "living like me in a district where it is rarely met with, the first time you saw this insect chanced to be, as it was in my case, one of those delightful evenings which an English summer seldom yields, when not a breeze disturbs the balmy air, and hundreds of these radiant worms, studding their mossy couch with mild effulgence, were presented to your wondering eye in the course of a quarter of a mile,—you could not help associating with the name of glow-worm the most pleasing recollections. No wonder that an insect which chiefly exhibits itself on occasions so interesting, and whose economy is so remarkable, should have afforded exquisite images and illustrations to those poets who have cultivated natural history."[1] However beautiful the effect produced by our own species, and by the fire-flies (*L. italica*), which are still more abundant over Italy and the rest of the south of Europe, their splendour, according to Humboldt, cannot be compared in richness to those innumerable scattered and moving lights that embellish the nights of the torrid zone, and seem to repeat on earth, along the vast extent of the savannahs, the spectacle of the starry vault of heaven. These, however, belong to a different tribe of insects (Elaterides), which resemble the glow-worm merely in their luminous properties; yet we cannot resist quoting the beautiful lines by Mr Southey, in which he describes their first effect on the earliest visitors of the new world.

.... Sorrowing we beheld
The night come on; but soon did night display
More wonders than it veiled; innumerous tribes
From the wood-cover swarm'd, and darkness made
Their beauties visible: one while they streamed
A bright blue radiance upon flowers that closed
Their gorgeous colours from the eye of day;
Now motionless and dark, eluded search,
Self-shrouded; and anon, starring the sky,
Rose like a shower of fire.[2]

The glow-worm is now a very rare insect in the neighbourhood of Edinburgh. Dr Neill informs us that it formerly occurred between the city and the village of Canonmills; but we have not heard of its having been found there or elsewhere around our immediate suburbs for many years. Dr David Ritchie has observed it occasionally near Pathhead, and Professor Wallace has met with it in Fife. Professor Wilson informs us that he once saw it on the Queensferry road, near Comely Bank. We have ourselves taken it by Loch Lomond side, and elsewhere in Scotland. It abounds in the north of England. We once received some living specimens early in July from Borthwick, about twelve miles from Edinburgh. They laid eggs a few days after their arrival, on the sides of a glass vessel. The parents soon after died, probably from being kept in too confined a space; but the young larvæ were hatched in a few weeks, and by the end of September they measured about the third of an inch in length. These larvæ bear a strong resemblance to the female perfect insect. The body is composed of twelve segments, of which the central are the largest. The three first segments bear each a pair of feet, and the caudal segments are slightly retractile within each other; and when the insect walks, which it does very leisurely, it bends its tail beneath it in such a way as to assist or support it in its progress. The head is very small, and is also retractile, and is usually withdrawn whenever the insect is alarmed or disturbed. These little creatures throve well in captivity. They were kept on a piece of moist mossy turf, which was frequently renewed; but whether they sustained themselves on the dewy herbage, or by means of the minute animal substances which it contained, it was not for a time very easy to discover. The curved and extended form of the little jaws would in the first place induce one to suppose that they were carnivorous. Olivier, however, observes, in his description of the larva of the glow-worm, "elle vie cependant sur de la terre fraîche, avec de l'herbe et des feuilles des différentes plantes; mais l'on a remarqué qu'elle devient foible et languissante, quand on la laisse manquer de terre humide. Elle est très-pacifique, et paroit craintive."[3] Fresh earth, or the moisture which arises from it, certainly seems necessary to their welfare, for we noticed that, when their turf became dry, and a slice of fresh apple or potato was introduced, they immediately settled on it, and inserted their heads as if drinking. We, however, soon after detected one with its jaws fixed in the head of a minute snail, which it appeared to be devouring, its own head being inserted into the aperture of the shell.

This observation appeared the more interesting, in as far as it served to connect those insects, by means of their habits, with that singular species the *Drilus flavescens,* which is known to feed voraciously on the *Helix nemoralis,* and the female of which was described by Mielzinski as the type of a distinct genus, under the name of *Cochleoctonus.* This latter insect is parasitical on the body of the helix, in the shell of which it dwells and undergoes its metamorphoses.

While engaged in the observance of these glow-worms, we met with a notice, in the *Annales des Sciences,* by a French gentleman of Rouen, on the same subject. In it we have ample proof of the carnivorous propensities of the creatures in question. He placed a great number of the larvæ in a vessel with fresh earth, and supplied them with various kinds of leaves. They soon however became extremely feeble, and remained so for several weeks, when he happened to put a dead slug in their jar, of which the young glow-worms were no sooner aware than they greedily seized upon it with their arched and sharp-pointed mandibles. On the ensuing day they were found to have eaten their way so far into the slug, that nothing but their tails was visible. They were perceived however occasionally to quit their prey and walk about upon the moist earth. The French naturalist was curious to observe how they would proceed with a living snail, and he therefore introduced one into his colony of insects. The animal soon began to crawl about its new domicile, but it no sooner came upon the path of a glow-worm than it was seized by the latter immediately beneath the mouth, and with such force and tenacity that it drew itself suddenly into its shell, and of course dragged its enemy along with it. The glow-worm however immediately disengaged its hold, and struggled back to the mouth of the shell, on the back of which it soon mounted, thus keeping the snail in a state of siege. Whenever it protruded even the point of its horns it was instantly seized, bitten, and obliged to withdraw within its fortress. The larva being soon joined by a companion, the two attacked the unfortunate snail, and

[1] *Introduction to Entomology,* vol. ii. p. 410.

[2] *Madoc.*

[3] *Entomologie,* t. ii. No. 28, p. 7.

after a continued combat of several hours, they put it to death, and by next morning it was not only slain, but eaten. These and similar experiments were made from the month of November to the month of June, after which the larvæ were observed to undergo their transformations. They occupied about a week in assuming the state of nymph—they continued in that state eight days longer—and then appeared in the form of the perfect insect. When about to assume the nympha state, the skin of the upper and anterior portion of the body cracks and opens, or a lateral division takes place on either side, so as to separate the skin of the upper from that of the under portion. By alternate elongations and contractions they then work their way forwards, and contrive to effect their liberation in a few minutes from their old attire. The nymph is larger than the larva, though not quite so long. Its colour is at first pale yellow, with two reddish spots on the posterior and lateral portion of each segment of the abdomen, as well as on the posterior angles of the thorax. It wants the large acute mandibles of the larva; its antennæ are very obvious, and consist of eleven articulations. The tarsi are likewise distinctly composed each of five articulations. The last rings of the abdomen are very brilliant, especially when the insect is handled; and it was noted as remarkable that the whole body partook, though with less intensity, of that phosphoric splendour which in the perfect insect characterizes only the terminal segments of the abdomen. Before the termination of the eight days which are passed in the nympha state, all the more delicate colours had disappeared, and were finally converted into those duller hues which distinguish the insect in its matured condition. As soon as it has disengaged itself from the slough of the larva, it bends its body into an arch or semicircle, and is then a genuine nymph, although it still continues to move its head, and even its limbs and antennæ. In this intermediate condition its general form has undergone no great change, but the head, feet, and antennæ are considerably altered, and seem enlarged or swollen. At first the body manifests a slow and heavy movement, which ere long ceases, and the antennæ and feet are then applied more closely to the sides of the body. The only signs of life now consist in a movement of the abdomen, which is bent into an arch, or occasionally moved from side to side. The body is shorter than that of the larva, the head is bent beneath the first segment or thorax, the antennæ consist of numerous articulations, and the caudal segment of the body, instead of being terminated by a couple of points, is now surrounded by eight of those points, in the centre of which are two fleshy tubercles, placed in a slight depression. Olivier had previously informed us that the nymph, after quitting the skin of the larva, shone with a very lively and brilliant light of a beautiful green colour, which became more splendid for a time when the vessel which contained it was moved, and disappeared again, as if by some voluntary action of the animal, even in the nympha state, in which the vital and instinctive powers are usually almost in a state of suspension. According to Degeer, the larva is also luminous. We have frequently observed the manifestation of that faculty in those in our keeping.

It has been a frequent subject of inquiry to ascertain the purposes which the light is intended to serve. In the perfect state the female continues wingless, while the male has become a swift-flying insect; and this has led to the supposition that the lambent flame, which is always most conspicuous in the female, is intended as a "nuptial lamp," to guide the male to her society. In this case, however, we do not so clearly see the use of it in the larva and nympha states, unless, to be sure, as a preparatory process for the formation of the animal phosphorus. Although many insects discover each other merely by the sense of smell, the fact seems nearly certain that the male or winged glow-worm ascertains his mate by aid of her luminous property; for it is a well-known and successful entomological device to place a female in a conspicuous position, and watch by her side, with a view to entrap the rarer or less visible males, which ere long make their appearance. Olivier has frequently caught the males by holding a female on the palm of his hand,—which makes it the more singular that he did not perceive the two luminous points which the former bears on the last segment of the abdomen,—"Je n'ai pas encore m'assurer, il est vrai, si le mâle de notre espèce commune a la propriété de luire." We may add, that the eggs are also beautifully luminous for some time after they are laid.

Dufour has examined the anatomical structure of the female glow-worm. The alimentary canal measures about twice the length of the body. The œsophagus is so short as to be nearly imperceptible. It dilates immediately into a short crop. The chylific ventricle is separated from the crop by a valvular contraction. It is long, smooth, that is, unprovided with papillæ, but pursed and cylindrical in its two anterior thirds, and intestiform in the remainder. The small intestine is very short.[1]

The matter from which the luminous property of the glow-worm results has been the subject of frequent experiment and observation. It is obviously under the control of the insect, which, when approached, may frequently be observed to diminish or put out its light.[2]

In the perfect female the luminous matter occupies chiefly the inferior part of the three last annuli of the abdomen. These differ from the rest in colour, and are usually of a yellow hue, especially on the under side. The light diffused is more or less intense, according to circumstances. The insect lives for a considerable time in a vacuum, and in various gases; but in nitrous acid, muriatic and sulphurous gases, it soon expires. When placed in hydrogen gas it has sometimes been observed to produce detonation. When the luminous portion of the body of a glow-worm is cut off, the insect continues to live, and the separated segments retain their phosphoric nature, and are luminous for some time, whether placed in vacuum, exposed to the air, or submitted to the action of different gases. By what means the living insect is able to shroud itself in darkness, and then suddenly to clothe itself as it were in a mantle of radiant light, is a subject beyond our power of investigation; but when dried the phosphorescence seems to depend on a certain degree of softness or humidity; for when apparently quite extinct, it may be reproduced by pressure, and the application of a little moisture. In the living state, however, although immersion in warm water produces a brilliant light, the application of cold water tends to its speedy extinction.

The next peculiarity in the history of the glow-worm consists in the change of its habits in regard to food, which takes place on its attaining maturity. From an insect of a predaceous nature, greedy of animal juices, it becomes entirely herbivorous, not much addicted indeed to food of any kind, but still confining itself, when it does indulge in eating, to the tender leaves of plants. It is

[1] *Ann. des Sciences Nat.* t. iii. p. 225.

[2] On this curious subject, however, we beg to refer the reader to the writings of Beckerheim (*Ann. de Chimie*, t. iv. p. 19), Caradori, and Treviranus, among foreign authors,—and to those of Mr Macartney (*Phil. Trans.* 1810), and Kirby and Spence (vol. ii. p. 423), among ourselves.

this circumstance which has no doubt led to so much contrariety of opinion on the part of entomological writers regarding its natural disposition. Most observers having attended to it chiefly after it had undergone its transformations, they naturally, and so far correctly, concluded that it was a herbivorous insect. Had they watched its progress from the egg they would have come to another conclusion, at least in regard to its earlier condition. This alteration in the habits of these creatures is in fact by no means unexampled, either among other genera of the same class, or among the more distantly related reptile tribes. The most familiar instance among the latter is the common frog, which in the early state of tadpole is herbivorous, while under the perfect form it preys on flies and other insects. In this case, to be sure, the order of change is inverted, the alteration being from a herbivorous to a carnivorous diet; while the contrary takes place in the glow-worm. But the analogy is more strictly maintained in the case of those aquatic beetles which form the family of *Helophoridæ*, which in the larva state are carnivorous, but become herbivorous after assuming their final transformation. The same singularity is also illustrated by many dipterous flies, which, born and bred amid the putrid moisture of animal remains, no sooner become winged insects, than they seek a purer diet in the nectarous juices of fruits and flowers.

In relation to the glow-worm, the observation is of more practical interest, because the appearance of the insect among our lawns and shrubberies is so extremely ornamental during the summer nights, that many have tried to import it to districts where it does not naturally occur. They have failed, in consequence of endeavouring to rear the young on vegetable food. Moist herbage, or a supply of damp earth, seems almost indispensable; but, in addition to these, their box must contain some minute testacea, such as the young of the ordinary species of the genus Helix. Perhaps the best plan is to hatch the eggs, and then place the young at liberty under an old hedge as soon as they have begun to eat freely.

2d, Antennæ decidedly remote at their base; head neither prolonged nor narrowed anteriorly in the form of a snout; the eyes of ordinary size in both sexes.

In genus Drylus, Oliv. (Pl. CCXXXVI. figs. 8, 9, and 12), the males are winged, and the inner side of the antennæ, from the fourth joint, is prolonged like the tooth of a comb. Those of the female are shorter, or somewhat perfoliaceous, and slightly serrated. The maxillary palpi in both sexes are thicker towards the extremity, and terminate in a point. There is a tooth on the internal side of the mandibles. The *D. flavescens* (see figs. last referred to) feeds, while in the larva state, on the *Helix nemoralis* of Linn. in the shell of which it dwells and undergoes its metamorphosis. It was on this account described by Comte Mielzinsky under the name of *Cochleoctonus.* Its history, and that of the other species, are now well known.[1]

All the remaining genera of this second division of the *Lampyrides* are winged in both sexes, and the maxillary palpi are not much longer than the labial. They correspond to the family *Telephoridæ* of English naturalists, and are composed chiefly of the species placed by Linnæus under the genus *Cantharis.* Schœffer and Degeer reserve that name to the species used in medicine, and apply the term Telephorus (probably from θελος φορεω, *I carry death*) to the remainder. The true Cantharidæ, therefore, are constituted by the genus Meloe, and the well-known blister-fly *C. vesicatoria*, &c.

In the genus Telephorus (Pl. CCXXXVI. fig. 11) the palpi are terminated by a securiform article, and the thorax offers no lateral emarginations. Their bodies are long, narrow, depressed, and of a soft or somewhat flexible consistence. These insects abound in meadows during the summer season, on umbelliferous and other plants. The larvæ are characterized by a flat scaly head, furnished with two strong teeth, a pair of small antennæ, and four palpi. Their bodies are flattish beneath, divided into twelve rings resembling those of caterpillars, and covered by a membranous skin, which is soft to the touch. The general colour of these larvæ is a deep velvety black, except the front of the head, which is shining. The antennæ, palpi, and feet are of a reddish or yellowish brown. They dwell in moist earth. Olivier was of opinion that they fed on roots, but the laborious and accurate Degeer asserts that they voraciously devour a great variety of insect prey. That of *Telephorus fuscus* was observed to change into the nympha state towards the end of May. It buried itself in the earth, but presented no appearance of cocoon. The nympha was about six lines in length, with the body somewhat arched, and of a pale-reddish white. The perfect insect was developed in the month of June. Even in the last-named state, in which so many species are chiefly occupied in the indulgence of other propensities, the Telephori, according to Degeer, continue their accustomed appetite. He has observed a female drag a male to the ground, turn him on his back, and suck out his entrails; so that, as among the spider tribes, considerable caution is necessary on the part of an inexperienced suitor while making his advances. Mr Curtis has frequently seen Telephori with other insects in their mouths. He once observed *T. lividus* eating an ichneumon, and he took another of the same species with an Empis in its mouth. *T. fuscus* is known to prey upon its own species. There are above thirty different kinds of this genus in Britain. Dejean, under the Linnæan name of *Cantharis,* enumerates 132 species. Whatever we know of the anatomy of these creatures accords with their apparent dispositions. Dufour has ascertained that their digestive canal is absolutely straight. Their biliary vessels are four in number, in which character, as well as in that of their generative system, they present a resemblance to the genus Lycus.

One of the most remarkable incidents in the history of the Telephori is the frequency with which, in some continental countries, the species are carried into the air in great quantities by violent winds, and unexpectedly deposited in distant regions,—thus giving rise to what are called *insect showers.* Sweden and Hungary have been most productive of such phenomena. One of the most ornamental of the British species, and the only one we shall here describe, is *T. cyaneus* of Curtis. The head is black and shining, but rufous before the eyes; the thorax and abdomen are likewise rufous, the elytra are deep blue, the legs black. This insect is pretty widely, though sparingly, distributed over the southern and central counties of Scotland, and the north of England. We have specimens from the Edinburgh district, from Kinordy in Forfarshire, from Dollar in Clackmannanshire, and from Dumfries and Roxburgh shires.

The genus Silis of Megerle differs from the preceding chiefly in having an emargination posteriorly on each side of the thorax. In Malthinus of Lat. (Pl. CCXXXVI. fig. 14) the palpi are terminated by an ovoid joint; the head is narrow behind; and the elytra, in several species, are shorter than the abdomen.

[1] See *Annales des Sciences Nat.* Jan. Juil. Aout, 1824; and *le Bulletin de la Soc. Phil.* for April of the same year.

Coleoptera Pentamera.

Tribe 3d, Melyrides.

Here we find the palpi generally short and filiform; the mandibles emarginated at the point; the body usually narrow and elongated; the head only covered at base by a flat or but slightly convex thorax, generally square, or elongated and quadrilateral; the joints of the tarsi entire, and the terminal hooks unidentated or bordered with a membrane. The antennæ are usually serrated, and even pectinated, in the males of several species. Most of these insects are of active habits. They occur on the leaves and flowers of plants.

In Malachius[1] of Fab. (Pl. CCXXXVI. fig. 13), there is a retractile and dilatable vesicle under each anterior angle of the thorax, and on each side of the base of the abdomen. Most of the species are adorned by ornamental and contrasted colours. The habits of the larvæ are but obscurely known. Olivier presumes that many of them live in wood, because he has frequently found the perfect insect in timber-yards, as if newly escaped from the nympha state. This is an extensive genus, and may be regarded as characteristic of temperate climes, although a few occur in Africa and the East Indies. Mr Stephens enumerates seventeen British species. Comte Dejean's collection contains 104 in all. Among the Melyrides with filiform antennæ, but of which the thorax and abdomen are unfurnished with retractile vesicles, Latreille places the genus Dasytes[2] of Paykul. The antennæ are at least as long as the head and thorax; and the body is generally narrow and elongated, sometimes linear. We have figured the male of *D, ater* (Plate CCXXXVI. fig. 15). In Melyris properly so called (Plate CCXXXVI. fig. 16), the antennæ are shorter than the head and thorax, insensibly enlarged, but without forming a club, as in *Lygia*. Their joints are also less dilated laterally, and are almost isometrical. The thorax is less convex.

In other Melyrides, such as Pelocophorus of Dej. the maxillary palpi are terminated by a larger and securiform article, a character which, with certain others, approximates them to the ensuing tribe. Dejean at one time placed them among the *tetramerous* species.

Tribe 4th, Clerii.

Distinguished by at least two of the palpi being projecting and clavate. The mandibles are dentated. The penultimate joint of the tarsi is bilobate, the first very short or but slightly visible in several. The antennæ vary, being in some nearly filiform and serrated, in others insensibly enlarged towards the extremity. The body is usually cylindrical, the head and thorax narrower than the abdomen, and the eyes emarginate. Most of these insects occur on flowers, some of them on the trunks of trees or in dry timber. The larvæ are regarded as carnivorous.

Of some the tarsi, viewed from above or from beneath, distinctly exhibit five joints. Such is the genus Tillus[3] of Olivier, in which the mandibles are cleft or bidentated at the extremity; the antennæ sometimes serrated, from the fourth joint to the tenth inclusively, with the last ovoid, sometimes terminating suddenly from the sixth in a serrated club. The terminal joint of the labial palpi is very large and securiform; the head short and rounded, and the third and fourth joints of the tarsi dilated in the form of a reversed triangle.

Of others the tarsi, when viewed from above, appear to consist of only four joints, the first being extremely short, or concealed beneath the second. Such is the genus Clerus[4] properly so called (Pl. CCXXXVI. fig. 17), in which the maxillary palpi are terminated by a compressed joint in the form of a reversed triangle, the last of the labial palpi, which are larger than the others, being securiform. The club of the antennæ is hardly longer than wide, and is composed of crowded joints; the third is longer than the second. The maxillæ terminate in a fringed and projecting lobe. The thorax is depressed anteriorly. The species, in the perfect state, occur on flowers. Their larvæ feed on those of certain bees. Dufour has described their internal structure. The crop is so short as to be almost entirely contained within the head. In Necrobia,[5] Lat. (Pl. CCXXXVI. fig. 19), the four palpi are terminated by an elongated, compressed, triangular joint of the same size; the second and third joints of the antennæ are almost equal, and the terminal club is elongated, and with looser articles. These insects occur chiefly in spring. They are said to live on carrion, and are richly adorned for such foul feeders. Deep blue is their prevailing colour. There are four species in Britain, of which we have as yet found only two in Scotland, viz. *N. ruficollis*, of a greenish blue, the thorax, base of the elytra, and legs rufous,—*N. violacea*, of a bright blue, shining yet pubescent, the antennæ and legs black. If the geographical notices which we have collected of the former species be correct, its distribution must be very extensive. It seems to occur both in Africa and the East Indies,—a wide circuit for an insect which we have taken behind the glass-works at Leith. "Insectum mihi carissimum," says Latreille, "illis enim infelicissimis temporibus quibus calamitatum omnium pondere obruta Gallia trepidanter gemebat, amicissime auxiliantibus Bory de Saint Vincent, Dargelas, Burdigalensibus, posteriori maxime, hoc animalculum mihi libertatis salutisque occasio miranda evasit."[6]

Tribe 5th, Ptiniores, Lat.

This tribe, consisting of the genus Ptinus of Linnæus, and of some others nearly allied, possesses a body of a tolerably firm consistence, in some cases almost ovoid or oval, and at others nearly cylindrical, but generally short, and rounded at either end. The head is nearly globular or orbicular, and is received almost entirely into a strongly arched or rounded thorax, resembling a hood. The antennæ of some are filiform, or diminished towards the termination, and are simple, flabelliform, pectinated, or serrated; of others they are terminated suddenly by three larger and longer joints. The mandibles are short, thick, and dentated beneath the point. The palpi are very short, and terminated by a larger article, almost ovoid, or like a reversed triangle. The tibiæ are not dentated, and the spurs at the extremities are very small. These insects are all of small size, exhibit little variety in their colouring, which is usually dark or sombre, and when touched they counterfeit death. Their motions are slow, and such as are winged seldom take to flight. In the larva state they are extremely destructive in museums.

In the genus Ptinus (Pl. CCXXXVI. fig. 18) properly so called, the antennæ are as long as the body, and inserted between the eyes, which are somewhat protuberant. The body is oblong. In the genus Ptilinus, Fab. (ibid. fig. 20), the antennæ, inserted before the eyes, are shorter than the body, and are pectinated or plumose from the

[1] From μαλακος, *soft.*
[2] From δασυτης, *shagginess.*
[3] From τιλλω, *to pluck or pull out.*
[4] The word κληρος is applied by Aristotle to an insect which inhabits hives.
[5] From νεκρος, *carcass*, and βιος, *life.*
[6] *Genera Crust. et Insect.*

third joint in the males[1]—serrated in the females. They inhabit old wood, in which they perforate deep round holes. In ANOBIUM, Fab. the antennæ are terminated by three larger or longer joints, the terminal one being ovate. The name of *Byrrhus*, originally bestowed upon the insects of the last-named genus by Geoffroy, was transferred by Linnæus to a very different group. His genus *Ptinus* included both *Ptilinus* and *Anobium*. Fabricius was the institutor of the genus Anobium, so called from *αναζιον*, *resuscitated*,—the species being characterized, in common with most of their congeners, by their frequent simulation of death, and their re-assumption of activity as soon as the threatened danger is removed. In this instinctive mode of preservation Olivier accuses them of exhibiting an invincible obstinacy. " Ils se laissent entièrement bruler sans donner aucun signe de vie." The larvæ of these insects are extremely injurious to old furniture, in which they perforate numerous round holes. Hence the genus is named vrillette by the French, from *vrille*, a gimlet. In the larva state they resemble small, white, soft worms, with six short minute feet. The head is scaly, and is terminated by two maxillæ in the form of strong cutting pincers, with which they gnaw the wood into the finest sawdust. When about to change into the nympha state, they line the bottom of their little cells with a few silken threads. Other species feed on flour, bread, sealing-wafers, &c. where they form grooves or galleries, according to the thickness of their working materials. The superstitious fancy of the *death-watch* has arisen partly from an insect of this genus, the *An. tesselatum*. It is supposed, however, to share this mysterious calling with the *Termes pulsatorium* of Linnæus, and probably with several others. According to Dr Shaw, it is in the advanced state of spring that the former of these insects commences its mysterious pulsations, which, he asserts, is nothing more than the signal-call of the sexes. The number of distinct strokes is generally from seven to eleven, and these are occasioned merely by its beating with its head with considerable force and quickness against the plane of its position. Where the insects are numerous, as is not unfrequently the case in old houses, these sounds may be heard during the whole day, especially in warm weather. The sound greatly resembles a moderate tapping on a table with the finger nail, and indeed by that simple process they may be induced to beat in reply when not otherwise inclined so to do. " He that could eradicate this error," says the quaint Sir Thomas Brown, in allusion to the death-tick, " from the minds of the people, would save from many a cold sweat the meticulous heads of nurses and grandmothers."[2] One of the most common species of the genus is *Anobium striatum*, of a somewhat pitchy-brown colour, the thorax obsoletely grooved, and produced towards the base into an elevated triangular ridge. This little timber borer, which is the *A. pertinax* of Fabricius, has been long famous for a most *pertinaceous* simulation of death. " All that has been related of the heroic constancy of American savages when taken and tortured by their enemies, scarcely comes up to that which these little creatures exhibit. You may maim them, pull them limb from limb, roast them alive over a slow fire,[3] but you will not gain your end; not a joint will they move, nor show by the least symptom that they suffer pain. Do not think, however, that I ever tried these experiments upon them myself, or that I recommend you to do the same."[4] This species was observed by Latreille to produce the sound called the *death-tick*, by striking its mandibles upon wood. On this occasion it was immediately answered from within by a precisely similar sound. We took a very rare British species, *A. abietis*, Fab. many years ago in a fir-wood near Edinburgh. *A. erythropum* of Leach is also stated by Mr Stephens to have been taken at Ravelston.

SECTION 3D, XYLOTROGI, Lat.

This final section of the SERRICORNES is distinguished from the two preceding by the freedom of the head, which is completely exposed and separated from the thorax by a strangulation or species of neck. It is composed entirely of the genus *Lymexylon* of Fab. as subdivided by recent writers.

In ATRACTOCERUS of Palisot de Beauvois, the elytra are extremely short, and in the form of little scales; the antennæ are compressed and almost fusiform; the thorax is square, the abdomen depressed. This limited and very anomalous-looking genus (it has the aspect of a *Staphylinus*) has representatives in Guinea, Brazil, and Java. A species is likewise known to occur in amber. In LYMEXYLON,[5] Fab. the elytra are as long or little shorter than the abdomen, the antennæ are simple, slightly if at all compressed, and almost moniliform. The thorax is nearly cylindrical. The *L. navale*, Fab. (of which *L. flavipes* of the same author is the male), is a small narrow insect of about half an inch in length, of a pale fulvous colour; the head, exterior margin, and extremity of the elytra black,—the latter colour more predominant in the males. This species is extremely common in the oak forests of the north of Europe, although unknown in Britain, and rare in the vicinity of Paris. Its larva is so long and slender as almost to resemble a *Filaria*. It multiplied so prodigiously some years ago in the dock-yards at Toulon, as to cause the destruction of great quantities of timber.[6]

FAMILY IV.—CLAVICORNES, LAT.

In this family, as in the preceding, we find four palpi, and elytra covering the upper surface of the abdomen, or its greater portion; but the antennæ are almost always thicker at the extremity, which frequently forms even a perfoliaceous or a solid club; they are longer than the maxillary palpi, and their base is exposed or scarcely covered. The legs are not fitted for swimming, and the joints of the tarsi, at least of the posterior ones, are usually entire. In the larva state they feed on animal matter. Latreille divides the tribe into two sections.

SECTION 1ST. Antennæ always composed of eleven joints, longer than the head, not forming from the third articulation a fusiform or nearly cylindrical club; the second joint not dilated in the form of an auricle. The terminal joints of the tarsi, as well as its hooks, of moderate length, or small. All the genera of this section are terrestrial. It comprises several tribes.

TRIBE 1ST, PALPATORES.

These, in a natural series, should be placed near the Pselaphii and Brachelytrous genera. Their antennæ are at least as long as the head, are slightly enlarged towards

[1] The generic name is no doubt derived from *πτιλον*, *a feather*,—in reference to the form of the antennæ.

[2] *Pseudodoxia Epidemica*.

[3] Degeer, iv. 229.

[4] *Introd. to Ent.* vol. ii. p. 235.

[5] From *λυμη*, *destruction*, and *ξυλον*, *wood*.

[6] *Règne Animal*, t. iv. p. 369.

Coleoptera Pentamera.

the extremity, or are nearly filiform; their first two joints are longer than those that follow. The head is distinguished from the thorax by an ovoid strangulation. The maxillary palpi project, and are long and inflated at the extremity. The abdomen is large, oval or ovoid, and laterally embraced by the elytra. The legs are elongated, the thighs clavate, the joints of the tarsi entire. These insects are found on the ground beneath stones and other substances. They form a single genus, divided by some writers into MASTIGUS and SCYDMÆNUS. The latter frequent moist places.

In all the following Clavicornes the head is generally sunk in the thorax, and the maxillary palpi are never at the same time advanced and club-shaped.

TRIBE 2D, HISTEROIDES.

This tribe is composed of the great genus *Hister* of Linnæus. The four posterior legs are more widely separated from each other at their origin than the anterior pair. The legs are contractile, and the exterior tibiæ dentated or spinous. The antennæ are always bent or *elbowed* (geniculate), and terminated in a solid mass, or composed of close-set articulations. The body is of a very solid consistence, and the elytra so hard that even the pin of the entomologist is with difficulty made to enter, and the præsternum is often dilated in front, and the elytra truncated. The mandibles are strong, and not unfrequently unequal as to size. The palpi are almost filiform, or slightly enlarged at their extremity, and terminated by an oval or ovoid article. In respect to their habits, the dentation of their tibiæ, and some other circumstances, these insects seem to exhibit an approach to the coprophagous LAMELLICORNES; but both Dufour[1] and Latreille[2] are of opinion that well-founded anatomical considerations connect them with the SILPHÆ. In the species (*H. sinuatus*) dissected by the former author, the digestive canal was found to be four or five times as long as the body. The œsophagus is extremely short; the oblong enlargement which immediately succeeds it exhibits throughout its parietes some brownish lines, which seem to indicate the existence of interior appendages proper for trituration; and if so, such enlargement may be regarded as the gizzard. The chylific ventricle is very long, twisted on itself, and beset with pointed and projecting papillæ. The hepatic vessels have six distinct insertions around the chylific ventricle.[3]

These insects feed on putrid and stercoraceous substances, decaying vegetables, &c. and some dwell beneath the bark of trees. Their movements are slow, their colour blackish, frequently with a tinge of bronze. Such of the larvæ as are known to naturalists affect the same food as the perfect insect. Their form, however, is different, being almost linear, depressed, smooth, soft, and of a yellowish white, with the exception of the head and first segment, of which the skin is scaly and of a brown or reddish colour. These larvæ have six short legs, and are terminated by a pair of articulated appendages, and an anal prolongation or tube. The scaly shield of the first segment is longitudinally channelled.

In some the tibiæ, at least the anterior ones, are triangular and dentated, and the antennæ always free and exposed, the body square, and slightly if at all inflated. Such is the genus HOLEPTA of Paykul, in which the body is much depressed, the mentum deeply emarginate, and the palpi formed of almost cylindrical joints. The species dwell beneath the bark of trees. In HISTER[4] properly so called (Pl. CCXXXVI. fig. 22), the præsternum projects beyond the mouth, and the palpi are composed of joints, the last excepted, rather in the form of a reversed cone than cylindrical.[5]

TRIBE 3D, SILPHALES.

In these and the remaining CLAVICORNES the legs are inserted at an equal distance from each other, and, with the exception of the eighth tribe (BYRRHII), the legs are not contractile, or at most the tarsi only can be bent upon the tibiæ, the mandibles are generally salient and flattened or not thick, and the præsternum is more dilated anteriorly.

In the SILPHALES we find five distinct joints in all the tarsi, and the mandibles terminate in an entire point without fissure or emargination.[6] The antennæ terminate in a club which is generally perfoliated, and composed of four or five articulations. The internal side of the maxillæ in some is furnished with a horny tooth. The anterior tarsi are frequently dilated in the males, and the exterior margin of the elytra of the greater number is marked by a groove with an obvious border. This tribe is composed of the genus SILPHA of Linnæus.

In the genus NECROPHORUS, Fab. so named from νεκρος, *a carcass*, and φορεω, *I carry* (Pl. CCXXXVI. fig. 21), the antennæ, scarcely longer than the head, terminate abruptly in an almost globular club of four joints, the first of which is long, and the second much shorter than the third The body forms nearly a parallelopiped; the thorax is widest anteriorly; all the tibiæ are strong, widened at the extremity, and terminated by strong spurs; the elytra are truncated at right angles. The maxillæ are destitute of a corneous claw.

This important and well-marked genus was first defined by Fabricius. Linnæus had placed the species of which it is composed with the Silphæ, while Scopoli and Geoffroy combined them with the genus Dermestes. The most marked peculiarity in their manners consists in their habit of interring small animals, such as mice and moles, for the purpose of depositing their eggs in their decaying carcass. To effect this operation, they remove the earth from beneath the dead body, which sinks into the hollow, and is afterwards covered with the looser soil of the excavation. Their sense of smell, like that of many other insects, is extremely delicate, and no sooner has any of the smaller quadrupeds perished, than one or more of these grave-diggers make their appearance, and in a few hours the corpse is interred. The larvæ are of a lengthened form, of a greyish-white colour, with a brown head. Their bodies are composed of twelve rings, furnished on their anterior and superior portion with a small scaly plate or shield, of a ferruginous brown colour; the shields of the last segments are provided with small elevated points. The head is hard, scaly, and furnished with strong cutting mandibles. The feet are six in number, very short, and attached to the first three segments of the body. When these larvæ have attained to their final term of increase, they descend, it is said, fully a foot beneath the surface, and, forming an oval chamber, the walls of which are strengthened by a coating of a gluey liquid, they as-

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1 *Annales des Sciences Nat.* Octob. 1824.

2 *Règne Animal*, t. iv. p. 491.

3 *Ibid.* Juil. 1825.

4 The generic name is supposed to be derived from *Histrio*, a word of Tuscan or Etruscan root, signifying an actor, and was probably bestowed in consequence of their instinctive propensity to simulate death when handled.

5 For the further divisions of this tribe, see Paykul's *Monographia Histeroideum*; and Leach's *Zoological Miscellany*, vol. iii.

6 In *Sphærites*, dentations are sometimes found on the internal side.

sume the nympha state. The perfect insect makes its appearance in the course of three or four weeks. There are seven species of this genus in Britain. Dejean possesses twenty-five. They are all of considerable size, and are chiefly from Europe and North America. We have received a specimen from Persia.[1] *N. vestigator* is black, the club of the antennæ, external margin of the elytra, and two transverse bands, orange yellow. *N. humator*, the most common species in Scotland, is a shining black, with the club of the antennæ ferruginous. Neither *N. mortuorum* nor *N. vespillo* (the species here figured) are very common in Scotland.

In Necrodes[2] of Wilkin (Pl. CCXXXVI. fig. 23) the antennæ are obviously longer than the head, and terminated by an elongated club of five joints, the second of which is larger than the third. Their body is oblong oval, the thorax almost orbicular, widest in the middle. The tibiæ are narrow, elongated, slightly enlarged at the end, and terminated by two ordinary spurs. The elytra are obliquely truncated. We have probably not more than one species in Britain, *N. littoralis* (the species figured), which is black, depressed, and oblong, with the thin terminal joints of the antennæ orange. It occurs on the seashore and the banks of rivers, beneath sea-weed, carrion, &c. and is found on the continent of Europe, along with *N. simplicipes*. The others occur in North and South America, New Holland, and Java.

In the genus Silpha[3] the body is almost shield-shaped and depressed, or but slightly elevated. The thorax is semicircular, truncated, or very obtuse before; the exterior margin of the elytra strongly recurved and guttered; the palpi filiform, with the last article almost cylindrical, and in many terminated by a point. Most of these insects feed on carrion, and thus contribute to the more speedy disappearance of putrid effluvia. Some climb upon plants, particularly the stems of wheat and other grain, where they find small *Helices*, on which they prey. Others dwell on trees, and feed on caterpillars.

The genus was originally of great extent, but has been much modified and circumscribed by Fabricius, Dejean, Latreille, Leach, and others. The species which it now contains resemble their congeners in being of an essentially carnivorous nature—preferring animal substances in a state of putrescence to fresher food. They exhale a disagreeable odour, and, when seized, a thick and dark coloured liquid exudes from their bodies. The larvæ resemble the perfect insects in their habits. They consist of twelve segments, of which the sides are terminated by sharp angles, the terminal segment being furnished with two conical appendages; the head is small, and bears a pair of tri-articulate filiform antennæ, and two strong maxillæ. Like the preceding genus, they undergo their metamorphoses under ground. The species are pretty extensively distributed over the earth, and are rather numerous. Dejean enumerates thirty-four species in his Catalogue, which, however, includes under the generic name of Silpha the genera *Oiceoptoma* and *Phosphuga* of Dr Leach. Of the restricted genus we have not more than eight British species. Most of these are deep black or dark brown. One of the most ornamental is *S. quadripunctata* (Pl. CCXXXVI. fig. 24), of which the margins of the thorax and the elytra are pale-yellow, the latter with two round black spots on each. We took this rare Scottish insect some years ago near Currie, in the vicinity of Edinburgh. It has since been brought to us from Loch Tay by Dr Greville. It is more frequent in England, where it frequents oak woods for the purpose of preying on lepidopterous larvæ.

Tribe 4th, Scaphidites.

In these the mandibles are cleft or bidentated at the extremity. The tarsi are composed of five very distinct and entire joints. The body is oval, narrowed at either end, arcuated or convex above, and thick in the middle. The head is low, and received posteriorly into a trapezoidal thorax, slightly bordered, broadest behind. The antennæ are generally as long at least as the head and thorax, and are terminated by an elongated mass of five articles. The terminal joint of the palpi is conical. The legs are slender and elongated. With the exception of the *Cholevæ*, the tarsi are nearly the same in both sexes.

In this tribe we place the genera Scaphidium[4] of Olivier, and Choleva of Spence;[5] of the former, *S. maculatum* is the only British species,—the rest inhabiting North and South America, and some of the continental countries of Europe. Of the latter, Mr Spence has described eighteen British species, arranged in three sections, of which some of the constituent parts are referable to the genus *Ptomophagus*[6] of Illiger and Knock, to *Luperus*[7] of Frœlich, and *Catops* of Fabricius and Paykul. Only two or three of Mr Spence's species belong to the genus *Choleva* in its present restricted form.

Tribe 5th, Nitidulariæ.

The Nitidulariæ approach the Silphales in their scutiform and bordered body, but the mandibles are bifid or notched at their extremity; the tarsi seem to consist of only four joints, the first and last, in some, being only visible beneath, where they form but a slight projection,—in others the penultimate is extremely small, in the form of a knot, inclosed within the lobes of the preceding. The club of the antennæ is always perfoliate, of three or two joints, and is usually short or but slightly elongated. The palpi are short and filiform, or somewhat thickest at the extremity. The elytra in several are short or truncated. The legs are but slightly elongated, and their tibiæ frequently widened at the end; the tarsi are furnished with hairs or pellets. These insects are of various habits, according to the species. They occur on flowers, in mushrooms, beneath the bark of trees, and even on putrid meat. This tribe is composed of the genus Nitidula, as subdivided into Colobicus, Thymalus, Ips, Nitidula (proper) (Pl. CCXXXVI. fig. 25), Cercus, and Byturus.

In the restricted genus Nitidula,[8] the antennæ are short, abruptly clavate, the radical joint large, thick, and somewhat orbicular, the third above one half longer than the fourth, the three last forming a club. Nearly thirty species occur in Britain. Many others are found in Europe and America.

Tribe 6th, Engidites.

These resemble the preceding in the emargination of the extremity of the mandibles, which however project but slightly, and that laterally, beyond the labrum. Their body is oval or elliptical, with the anterior extremity of the head a little advanced in an obtuse or truncated point.

[1] For notices of their anatomical structure, see Dufour, in *Ann. des Sciences Nat.* for October 1824 and July 1825.

[2] Probably from νεκρωδης, *cadaverous.*

[3] The word *Silpha*, derived from a Hebrew root, occurs in Aristotle, and appears to have been sometimes used by that author to signify a *cockroach.*

[4] From Σκαφη, *a boat*, and ιδεα, *form.*

[5] *Linn. Trans.* vol. xi.

[6] From πτωμα, *a carcass*, and φαγω, *I eat.*

[7] From λυπηρος, *troublesome.*

[8] From *nitidus*, shining, or bright.

The tarsi consist of five distinct joints, entire, and at most only slightly pilose beneath, the penultimate being somewhat shorter than the preceding joint. The antennæ terminate in a perfoliate club of three articulations. The elytra completely cover the abdomen, and the palpi are somewhat thickened at the extremity. Some very minute species live in the interior of houses, and are frequently found on window-sashes. They constitute the genus DACNE, divisible into, 1*st*, *Dacne* proper (*Engis*, Fab. *Erotylus*, Oliv.), in which the antennæ terminate abruptly in a rather large, orbicular, or ovoid and compressed club, composed of crowded articulations, of which the central one at least is much wider than long, and the third longer than that which precedes and follows; the centre of the posterior margin of the thorax is dilated behind or lobed, and the upper extremity of the mentum is advanced, and terminated in a truncated or bidentated point: 2*d*, *Cryptophagus*,[1] Herbst, Lat. (*Dermestes*, Linn. *Ips*, Oliv. *Antherophagus*, Knock), in which the antennæ are moniliform, with the second article as large or larger than the preceding, and terminate in a less abrupt and narrow club than in *Dacne*, and with intervals between its segments. This is a pretty extensive genus, occurring in various parts of the world, but chiefly in European countries. We have fourteen species in Britain.

In Latreille's arrangement (*Règne Animal*, t. iv. p. 508) we now come to certain tribes in which the præsternum is frequently dilated anteriorly in the manner of a chin-cloth (*mentonnière*), and which differ from the preceding in their legs being more or less contractile. The tarsi may be free, but the tibiæ, at least, are folded upon the thighs. The mandibles are short, usually thick, and dentated. The body is ovoid, thick, and furnished with deciduous scales or hairs of various colours. The antennæ are generally straight, and shorter than the head and thorax. The head is sunk into the thorax as far as the eyes. The thorax itself is but slightly if at all bordered; it is trapezoidal, and wider posteriorly, the middle of the posterior margin being frequently somewhat prolonged or lobate. The larvæ are pilose, and dwell for the greater part on the skins or carcasses of animals. They are hurtful in museums. Those in which the legs are not completely retractile, the tarsi being always free, and the tibiæ lengthened and narrow, form

TRIBE 7TH, DERMESTINI.

In DERMESTES proper (so called from δεϱμα, *skin*, and εσθιω, *to eat* or *consume*) the antennæ are shorter than the thorax, the radical joint large and ovate, the seven following short and slender, the remaining three forming an ovate compressed club, of which the two lower joints are somewhat dilated in the inner side, the terminal being smaller and rounded. They are not received in a particular groove beneath the thorax. *D. lardarius* (Plate CCXXXVI. fig. 27) is black, pubescent, the elytra with a broad cinereous band across the base, in which are three brownish or black spots. In ATTAGENUS the club of the antennæ is proportionlly very large, almost serrated, and composed of three articles, of which the first and last, especially in the males, are the largest. The body is ovoid, short, slightly convex. The terminal article of the maxillary palpi is large and ovoid. In ANTHRENUS[2] the club of the antennæ is more solid than perfoliate, and is in the form of a reversed cone, and lodged in a short cavity, hollowed beneath the anterior angles of the thorax. In the larva state these insects live on dried animal matters, particularly on the contents of entomological cabinets. In that condition they are oval, and furnished with hairs, some of which are dentated; they form aigrettes or tufts, of which the hinder are prolonged in the form of a tail. In the perfect state they are found among flowers. Other genera, such as *Limnichus* of Ziegler, *Trogoderma* and *Globicornis*, Lat., pertain to this tribe.

TRIBE 8TH, BYRRHII.

This tribe is composed principally of the genus *Byrrhus* of Linn., and differs from the preceding in its feet being entirely contractile, the tibiæ being susceptible of being bent upon the thighs, and the tarsi upon the tibiæ, so that the species, when their limbs are thus contracted, appear inanimate and without legs. The latter are usually broad and compressed. The body is short and convex.

In NOSODENDRON, Lat. (of which we have one British example, *N. fasciculare*), the mentum is entirely exposed, large, and buckler-shaped. In BYRRHUS proper the mentum is of ordinary dimensions, and as it were interlocked, at least partially, by the præsternum, of which the anterior portion is dilated. The larvæ of these insects have been studied by M. Wadouer. Their heads are large, their bodies narrow and elongated, with the two terminal segments more extended than the others; the first, or that of the prothorax, presents superiorly a large corneous plate. The genus was confounded by Degeer with *Dermestes*, and with *Cistela* by Geoffroy. The species occur in fields, woods, and sandy places. They are not unfrequent by the side of highways, and although they can fly with facility when they choose, they rarely exercise that faculty. When handled or even approached, they apply their legs and antennæ so close to the body as to exhibit the appearance of a little ball, and in that state they simulate death with great perseverance. Of eight or nine species found in Britain, we shall here name only *B. æneus*, an interesting species, lately added to the British Fauna by the Rev. James Duncan. It is oblong-ovate, brassy green above, scutellum whitish, the elytra irregularly punctured, and without striæ. It was found in an open part of a wood near Newbattle House in Mid-Lothian. It has since occurred under stones on Musselburgh Links, has been taken in Dumfriesshire, and was met with by Dr Greville in considerable numbers near the ferry of Kylestroem in Sutherland. There are thirty-three species in Dejean's collection.

SECTION 2*d*. The CLAVICORNES of this section, although forming a good natural group, can only be characterized by the assemblage of several features. Some which are nearest to the PALPICORNES have antennæ of only nine or even six joints. Others have ten or eleven joints to these organs, which are sometimes scarcely longer than the head, and from the third joint form an almost cylindrical or fusiform club, arcuated and somewhat serrated; sometimes nearly filiform, and as long as the head and thorax. In this case, as well as among most of the other genera of the same division, the tarsi are terminated by a large joint, with two strong hooks at the end. In certain genera, such as *Heterocerus* and *Georyssus*, these parts consist of only four articulations. The form of the body in this section is generally ovoid, with the head sunk up to the eyes in a trapezoidal thorax laterally bordered, and terminated posteriorly by acute angles. The præsternum is dilated poste-

[1] From κϱυπτος, *hidden*, and φαγος, *eating*.

[2] Ανθϱηνη is the ancient name of an insect which dwelt among flowers,—a kind of bee.

riorly (the Potamophili excepted), and the legs are imperfectly contractile. They usually occur in water, beneath stones by river sides, or in mud. They form two tribes.

TRIBE 1ST, ACANTHOPODA.[1]

Remarkable for their broadish flattened legs, armed exteriorly with spines. The tarsi are short, of four articulations,[2] the hooks of ordinary size. The body is depressed, and the præsternum dilated. The antennæ are rather longer than the head, arcuated, and composed of eleven joints, of which the last six constitute an almost cylindrical and slightly serrated club, the second being short and not dilated. This tribe is composed of the single genus HETEROCERUS[3] of Bosc (Pl. CCXXXVI. fig. 26).

TRIBE 2D, MACRODACTYLA.[4]

Here are included such of the Clavicornes as have simple narrow tibiæ and lengthened tarsi, all composed, except in Georyssus, of five articulations, the last of which is large, with strong terminal hooks. The body is thick or convex,—the thorax less rounded, and usually terminated on both sides by acute angles.

The type of this tribe is formed by the genus *Dryops* of Olivier—*Parnus*, Fab. We here place the genus ELMIS,[5] of which the species, pretty frequent in Britain, occur in water, beneath stones, or on the leaves of water-lilies. In PARNUS proper (*Dryops*, Lat. Oliv.) the antennæ, shorter than the head, are lodged in a small cavity beneath the eyes, the second joint being compressed and much produced,—concave for the reception of the remaining joints, which form a serrated mass attached by a small peduncle near the base. *P. prolificornis* is oblong, olive brown, villose, with the elytra thickly punctured, and obscurely striated towards the sides and apex. It occurs in moist places by the sides of ponds and marshes, not unfrequent during spring. Here are also placed the genera *Potamophilus* of Germar, *Macronychus* of Müller, and *Georyssus* of Latreille.

FAMILY V.—PALPICORNES.

In this family, as in the preceding, the antennæ are terminated by a kind of club, usually perfoliate, but composed at most of only nine articulations, and inserted beneath the advanced and lateral margins of the head, and scarcely longer than it and the maxillary palpi,—frequently even shorter than these last-named organs. The mentum is large and buckler-shaped. The body in this family is generally ovoid or hemispherical, and arched or convex. The feet in most of the genera are formed for swimming, and these present either four articulations to the tarsi, or five, of which the first is much shorter than the second: the whole are entire.

TRIBE 1ST, HYDROPHILII.

Feet fit for swimming. First article of the tarsi much shorter than the others. Maxillæ entirely corneous. Of this tribe (genus *Hydrophilus* of Geoffroy) Linnæus formed only a division of his genus Dytiscus. Their anatomical structure however differs in many important particulars from that of the true Dytisci. The digestive canal, which is four or five times as long as the body, presents a strong analogy, both in its length and texture, to that of the Lamellicornes, and differs from that of the Carnivora except as regards the biliary vessels. We perceive neither the swimming bladder nor the excrementitial apparatus, such as these exist among the Hydrocanthari. In the females only, the latter is replaced by secreting organs fitted for the formation of a cocoon to contain the eggs. The sexual organs of the male bear a great resemblance to those of the preceding family. These and other considerations have induced M. Latreille to place them here. The species are more convex in their general forms than the Dytiscidæ, and their antennæ are dissimilar; but in many of their instincts and habits of life, and in their general transformations, they bear a resemblance to that group. The largest water insect of Great Britain (*Hydrophilus piceus*), which we have failed as yet to discover in Scotland, belongs to this division. Many species are also extremely minute.

In the genus HELOPHORUS of Leach (from ἕλος, *a marsh*, and φορεω, *I penetrate*) the antennæ are shorter than the head, the first joint is the longest, robust, and slightly curved, the second shorter than the first, the three following minute, the last four forming the club. *H. aquaticus* (Plate CCXXXVI. fig. 29) abounds in almost every pond. It is almost always found covered with mud, in such an ingenious manner that, when feeding in its little pool, it is with difficulty distinguished from the subjacent soil, either by its natural enemies, or the no less dangerous eye of the practical entomologist. *H. granularis* is more frequently found upon the wing in situations remote from water. In HYDROCHUS of Germar (from ὕδωρ, *water*, and οικεω, *to inhabit*) the general form is narrower and more elongated, the thorax like a lengthened square, and the eyes prominent. *H. brevis*, a rather scarce species, occurs in the Edinburgh district in ditches near Craigcrook, and in the Braid marshes. As allied to the preceding genera we may here name ENICOCERUS of Stephens (so called from ενικος, *singular*, and κερας, *horn*). The antennæ are as long as the head, the basal joint long, curved, slightly geniculate at the base, the second ovate-truncate, three or four following very minute and obscure, the last five of nearly equal thickness, penultimate cup-shaped, terminal orbicular. *E. viridiæneus*, of a brassy green, thorax with an oblique groove near each of the hinder angles, and two foveæ in front, the legs piceous. Although a newly described insect, it does not seem at all scarce in Scotland, where it occurs beneath small stones by the margins of water, or imbedded among mud and confervæ. In the genus SPERCHÆUS, Fab. the antennæ have only six joints, and the clypeus is emarginate. In HYDROPHILUS,[6] properly so called, of Leach, the tarsi are identical in both sexes and not dilated, the pectoral spine terminates with the præsternum, and the scutellum is proportionally small. *H. caraboides* is the only British species. The genus HYDROUS of the last-named author[7] (*Hydrophilus*, Lat.) is characterized by the great extension backwards of the sharp-pointed sternal spine, and by the triangular-shaped dilatation of the last article of the two anterior tarsi of the males. The scutellum is large. *H. piceus* (Pl. CCXXXVI. fig. 28), the only British species, is one of the largest of the European Coleoptera. It measures above an inch and a half in length, is of an oval form, a blackish-brown colour, with a polished or shining surface. The club of the antennæ is partly reddish. A

[1] From ακανθα, *a thorn* or *spine*, and πους, *foot*.
[2] According to the accurate Gyllenhal, there are actually five, the first being small and oblique. (*Insecta Suecica*, t. i. p. 138.)
[3] From ἑτερος, *different*, and κερας, *horn*.
[4] From μακρος, *long*, and δακτυλος, *finger*.
[5] The name is applied by Galen to a species of intestinal worm.
[6] From ὕδωρ, *water*, and φιλος, *a lover*.
[7] *Zoological Miscellany*, vol. iii. p. 94.

few slight striæ are visible on the elytra, of which the posterior extremity is rounded posteriorly, and prolonged to a small tooth at the inner angle. This fine insect flies well and swims swiftly, but is inefficient as a pedestrian. When held loosely in the hand it sometimes inflicts a wound with the point of the sternum. The female constructs an ovoid cocoon, arcuated, and of a brown colour. Its exterior tissue is composed of a gummy paste, at first somewhat fluid, which soon hardening, becomes impenetrable by water. The eggs which it envelopes are symmetrically disposed, and kept in their position by a sort of whitish down. These cocoons float in the water.[1] The larva is depressed, blackish, and rugose; the head reddish brown, smooth, round, and capable of being drawn backwards. This peculiar faculty gives it the power of seizing whatever small shells or other living prey it may perceive floating on the surface. Its back serves it as a kind of table, on which it bruises its prey. The bodies of these predaceous larvæ become very flaccid as soon as they are caught. They swim with facility, and are provided beneath the anus with two fleshy appendages, which serve to maintain them at the surface of the water when they ascend to breathe.[2] They are called on the continent *vers-assassins*, on account of their greedy and ferocious nature. They become more herbivorous in the perfect state.

In Limnebius of Leach (from λιμνη, *a marsh*, and βιος, *life*), the antennæ are short, slender, the club six-jointed; the maxillary palpi longer than the antennæ, with the terminal article shorter than the preceding, and cylindrical. In this tribe are likewise included the genera *Hydrobius* and *Berosus*.

Tribe 2d, Sphærodiota.

These Palpicornes differ from the preceding in being terrestrial. Their tarsi consist of five distinct articulations, of which the first is at least as long as the following. The maxillary palpi are shorter than the antennæ, with the third joint larger, inflated, and in the form of a reversed cone. The maxillary lobes are membranous. The body in this tribe is almost hemispherical, with the præsternum prolonged to a posterior point, and the tibiæ spinous, the anterior being palmated or digitated in the larger species. The antennæ are always composed of nine articles, or simply of eight, if we regard the terminal one as an appendage of the preceding. The genera are Cercyon of Leach, and Sphæridium[3] of Fabricius (Plate CCXXXVI. fig. 30). The former is abundant in Britain, where we find about sixty species, many of which occur in Scotland.[4] Few are as yet ascertained to inhabit extra-European countries, although one or two occur in North and South America. All the species of this tribe are of small size. They usually occur in cow-dung, and excrementitious matter. Some are found on the margins of water.

FAMILY VI.—LAMELLICORNES.[5]

This is the last family of the pentamerous Coleoptera, and one of the most remarkable of the order,—whether we consider the great size of many species, the singularly varied forms of their head and thorax, or the richness of the metallic colouring with which the vegetable-eating kinds are frequently adorned.

The antennæ, inserted in a deep groove beneath the lateral margin of the head, are always short, and composed generally of nine or ten articulations; they are always terminated in a club or mass, which usually consists of three joints, expanded in the form of thinnish plates or leaves, disposed in various ways,—like the spokes of a fan, the leaves of a book, the teeth of a comb, or a series of funnels placed above and within each other. The body is generally ovoid or oval, and thick. The exterior edge of the two anterior tibiæ are toothed, and the articles of the tarsi, with the exception of certain males, are entire, and without brush or pellet beneath. The anterior extremity of the head is advanced and dilated in the form of a clypeus or epistoma. The mentum is usually large, covering the ligula, or incorporated with it, and bearing the palpi. The mandibles of many are membranous, a character scarcely if at all to be observed in any other Coleoptera. The males are frequently very different from the females, being distinguished by horn-like elevations on the head and thorax, and by the greater size of the mandibles. Linnæus indeed founded the sections of his great genus Scarabæus in accordance with these peculiar projections, while Scopoli assumed the spines or teeth of the fore-legs as the distinguishing characteristic of his subdivisions. The latter author likewise proposed two other methods, one of which regards the number of articulations in the clava of the antennæ, and the other takes into consideration the varying manners of the insects themselves. The former of these is extremely defective, the second is chiefly deserving of consideration as exhibiting the first attempt ever made towards a natural arrangement of these insects. They are divided into *Anthophylli*, *Phyllophagi*, and *Stercorei*.

Degeer was the first to avail himself of the improvements indicated by Scopoli, while at the same time he avoided his principal imperfections. He arranged the Scarabæi into three families, as follows: 1*st*, *Scarabées de terre;* 2*d*, *Scarabées des arbres;* 3*d*, *Scarabées des fleurs*. Oryctes and Trox were no longer regarded as phyllophagous insects.

Geoffroy separated from Scarabæus of Linnæus the exscutellated species under the name of *Copris*, and Scopoli's genus Lucanus under the name of *Platycerus*. The institution of the genus Copris was certainly an improvement, although it was founded on such defective characters, that coprophagous insects, such as the family Geotrupini of Latreille, were included in the same genus with Cetonia, from which they might have been perceived to be distinct so soon as the necessity was admitted of carrying the investigation among the *Lamellicornes* somewhat beyond that first affinity—the form of the antennæ.

At a still later period Fabricius further improved upon the heterogeneous composition of Geoffroy's genus Scarabæus, by taking from it the genera *Trox*, *Melolontha*, *Cetonia*, and *Trichius*. But the re-union of Geoffroy's genus Copris with Scarabæus was a retrograde step which the entomologist of Keil afterwards corrected in a supplementary work. The connection, however, between the insects afterwards named *Geotrupes* by Latreille and the genus Copris of Geoffroy, was so far re-established by the formation of the Fabrician genus Scarabæus.

Olivier adopted the genus Scarabæus of Fabricius, with all his other genera except Trichius, and divided it into

[1] For a detailed and accurate account of the structure and transformations of this insect, see a posthumous work of the celebrated Lyonnet, lately published under the title of *Recherches sur l'Anatomie et les Metamorphoses de differentes espèces d'Insectes*.

[2] *Annales du Museum d'Hist. Nat.* t. xiv. p. 441.

[3] From Σφαιρηδιον, *globe-shaped*.

[4] See *Ent. Ed.* p. 139.

[5] From *lamella*, a little plate, and *cornu*, a horn, in allusion to the structure of the club of the antennæ.

the following sections: 1*st*, Those furnished with mandibles, but unprovided with a labium; 2*d*, those furnished with mandibles and a labium; 3*d*, those which have neither mandibles nor labium. The three groups just mentioned are characterized by Mr Macleay as strictly natural.[1]

This important family, in the system of Latreille, seems to include all those insects classed by Linnæus in the old genera *Scarabæus* and *Lucanus*. The lamellicorn tribes, indeed, include a very numerous assemblage, many of which, especially such as feed on flowers and living vegetation (called *Thalerophaga* by Macleay), are remarkable alike for beauty of form and splendour of colour. Most of those, however, which feed on decomposed vegetables, or excrementitious substances, are usually of a more uniform black or brownish hue. But even the coprophagous kinds sometimes surprise us by their beauty, and present a singular contrast when disentangled from their repulsive habitations. They are all winged insects, although for the most part rather dull and heavy in their movements.

The larvæ are long, semi-cylindrical, soft, of a whitish colour, and divided into twelve rings or segments. The head, of a harder consistence, is armed with strong mandibles. The feet are six in number, and squamous or of a scaly texture. On each side of the body there are nine stigmatic openings. The posterior extremity is the most bulky; it is rounded and almost always curved inwards, in such a manner as to prevent the larva from extending itself in a straight line. Its motions are consequently slow and awkward, and when crawling on the surface it frequently rolls over or falls on one side. The nympha or intermediate state is in some instances not assumed till after the lapse of several years. Immediately preceding the assumption of that state the larva protects itself by means of a cocoon of an oval form, composed of earth and the gnawed fragments of other materials, agglutinated by a viscous secretion which exudes from its body. These larvæ seek their food in the dung of cattle, in tan pits, in gardens where rich vegetable mould occurs, and among the roots of plants. In regard to their interior structure, it has been observed that the nervous system, when studied in the different stages of life, presents a considerable dissimilarity. The ganglions are less numerous, and approximate more to each other, when the insect has reached the term of its final transformation; and the two posterior ganglia throw out numerous filaments disposed in a somewhat radiated form. In the larva the trachea is elastic, but simply tubular in the perfect insect. The structure of the eye in most of the lamellicorn beetles exhibits characters analogous to those of the Tenebrionites, the Blattæ, and other lucifugous or light-shunning species.

The alimentary canal is of great length, especially among the coprophagous kinds; and the chylific ventricle is beset with papillæ, which, according to the investigations of M. Dufour, serve as the receptacles of the alimentary fluids. The biliary vessels resemble those of the carnivorous Coleoptera in number and position, but they differ in being of greater length and much more slender. Latreille divides this important family into two tribes.

Tribe 1st, Scarabæides.[2]

These correspond to the unrestricted genus *Scarabæus* of Linn. Their antennæ are terminated by a foliaceous club, generally capable of being alternately closed or expanded; or are composed of joints that fit into each other, either in the form of a reversed cone, or nearly globular. The mandibles are of identical form, or nearly so, in both sexes; but the head and thorax of the males frequently exhibit projections or peculiar forms. The antennæ in the latter sex are frequently more fully developed than in the females. The alimentary tube in these insects is generally much longer than that of the following tribe, and the œsophagus is proportionally shorter. But it is chiefly by the genital system of the males that the Scarabæides are distinguished, not only from the tribe with which they are conjoined, but from all other pentamerous Coleoptera. The larvæ have a cylindrical stomach surrounded by three ranges of small cæca, the small intestine very short, the colon extremely thick and turgid, and the rectum of moderate size. A prodigious accession of fine typical forms has been received of late years by this division of Entomology, far beyond what we are able to indicate in this work.[3] We shall, however, notice the most important and remarkable genera, and illustrate many of these by means of the plates connected with this department of the Encyclopædia.

The following sections are established on the consideration of the masticating organs, the antennæ, and the habits, and have been confirmed by the anatomical researches of M. Dufour.

Section 1st, Coprophagi.[4]

In some of these the antennæ are formed of nine, in others of only eight articulations; the three terminal ones forming the club. The labrum and mandibles are membranous and concealed. The terminal lobe of the maxillæ is also of the same consistence, broad and arcuated at the upper margin, and curved inwards. The terminal article of the maxillary palpi is always the largest of all, nearly oval or almost cylindrical; but that of the labial palpi is almost always more slender than the preceding, or very small. Behind each of these latter palpi is a membranous projection, in the form of a ligula. The mentum is emarginate. The sternum presents no particular projections, and the hooks of the tarsi are always simple. The anterior tarsi are frequently wanting in certain species, either naturally or because they are deciduous. The extent of the alimentary canal is always very great, occasionally (as in *Copris lunaris*) even ten or twelve times the length of the body. The chylific ventricle occupies the greater portion; it is beset with papillæ, conoid or in the form of nails, folded on itself, and maintained in that state of agglomeration by numerous tracheal bridles. The intestine is filiform, but terminates in an enlargement. "Les testicules des coprophages disséqués par M. Dufour, lui ont paru composés de six capsules spermatiques, orbiculaires, un peu deprimées ordinairement réunies, par des trachées, en un paquet, portées chacune sur un pédicule tubuleux, assez long, et qui aboutit à un canal déférent de peu de longueur. Il n'y a qu'une

[1] *Hor. Ent.* p. 17.

[2] The *Scarabæidæ*, as restricted by Macleay, are chiefly tropical forms, that is, the species in the warmer regions of the earth are to those from beyond the tropics nearly as five to one. Out of 450 species and upwards, in the collection of Mr Macleay senior, only nine are natives of England, and of these eight are *Onthophagi*.

[3] Comte Dejean informs us that his collection now contains 2060 species of *Lamellicornes*, among which he has found himself under the necessity of establishing 76 new genera.

[4] From κοπρος, *dung*, and φαγος, *eating*.

Coleoptera Pentamera.

paire de vesicules séminales; elles sont filiformes, très longues et fort repliées."[1] Our present section corresponds to the third division of the genus Scarabæus of Olivier (*Copris*), with the addition of some other Scarabæi (*Aphodii*) of that author.

*

In some the intermediate pair of legs are much more remote from each other at the base than the rest; the labial palpi are hairy, with the terminal articulation much smaller than the others, or even indistinct; the scutellum is either null or extremely small.

Coprophagi of this division, peculiar to the eastern continent, with a rounded body, usually depressed above, or but slightly convex, similar or differing little in the sexes, and without horns; the antennæ of nine joints, terminated by a foliated club; without either scutellum or a sutural hiatus indicating its place; the four posterior tibiæ, usually furnished, as well as the tarsi, with ciliated or hairy fringes, and slender, elongated, not dilated at the extremity, or but slightly so, truncated obliquely, and terminated by a single strong-pointed spur; with the epistoma more or less dentated;—these form the genus Ateuchus[2] of Weber and Fabricius. (Pl. CCXXXVII. figs. 1 and 2.)

The above genus, however, has been since restricted to such species as have the exterior margin of the elytra straight or unemarginated, and without a sinus, near the base, leaving exposed the corresponding portion of the upper margin of the abdomen. The tibiæ and tarsi of the last four legs are furnished with long hairs; the first four articles of the tarsi are generally longer than the others. The first joint of the labial palpi is almost cylindrical, or in the form of a reversed cone. The epistoma is generally divided into three lobes or festoons, and its contour presents six teeth. The *Ateuchi* form the genus *Scarabæus* of Macleay.[3] These insects deposit their ova in dung, which they form into balls, and roll along with their hind legs till they find a hole adapted to receive them, or a softish soil in which they may be buried. Two species were worshipped by the ancient Egyptians, and form a noted and conspicuous feature in the hieroglyphical system of that mysterious nation. We still find them sculptured on their monuments, in various positions, and sometimes of gigantic size. They were also formed into separate figures, as seals and amulets, composed of gold and other precious materials, and hung around the necks of the living, or buried along with their famous mummies. The insect itself in the natural state is also sometimes found in their gaudy coffins.

The *Ateuchus sacer* (Pl. CCXXXVII. fig. 2) occurs not only in Egypt, where it formed an object of superstitious worship, but over a great portion of the south of Europe. It is also found in the western regions of Asia. Another species, discovered in Sennaar by M. Caillaud, was, however, according to M. Latreille, the first to attract the notice of the Egyptians.[4] It is named *A. Egyptiorum* (ibid. fig. 1), and, instead of being black like the former, is green with a golden hue. The occiput also, instead of being bi-tuberculated, exhibits only a slight elongated eminence, which is smooth and shining.

In Gymnopleurus of Illiger, the exterior sides of the elytra are strongly emarginate near the base. The four posterior tibiæ are in general simply ciliated, or furnished with small spines, and the last article of the tarsi is as long, if not longer, than all the preceding ones taken together. The first article of the labial palpi is dilated internally and almost triangular. There is a fossula on each side of the thorax.[5]

Other Coprophagi, nearly allied to the preceding, and likewise placed by Fabricius among the Ateuchi, are distinguished by the intermediate tibiæ, the extremities of which, as well as of the two hinder ones, are frequently clubbed or dilated, and present two spurs or spines. The epistoma in many has only four or two teeth. The first article of the labial palpi is always larger than the following, and dilated on the internal side. The third and last article is distinct. We shall here name only the genus Sisyphus, which differs from the others in having only eight joints in the antennæ. The form of the abdomen is triangular, and the intermediate and hind legs are long and narrow, with the thighs clubbed.

In all the ensuing Coprophagi the intermediate and hind tibiæ are always dilated at their extremity, and almost in the form of a lengthened triangle; the intermediate pair terminate, like those of the preceding, in two strong spines; but the head or thorax, or both these parts, of the males, are distinguished by horns or marked projections. In several the last three articulations of the antennæ are semi-cupular, and concentrically fitted into each other. These insects are referable to the genera *Onitis* and *Copris* of Fabricius.

The genus Onthophagus,[6] Lat. (ibid. fig. 3) (which, in common with Oniticellus of Dejean, has the third joint of the labial palpi small or indistinct, and the preceding larger than the first), exhibits a short body with a thickish thorax, broader than long, and semi-orbicular or nearly orbicular, but strongly emarginate or truncated in front. The head, and frequently the thorax also, is horned in the males. The scutellum is not apparent. Of this genus we have eight or ten species in Britain. Dejean's Catalogue contains 150. Some beautiful species of small size occur in Africa and the East Indies. They are likewise met with in New Holland, where they constitute the principal portion of the coprophagous beetles, which seem rare in that vast region, a circumstance attributed by Mr Macleay to the absence of all large herbivorous mammalia, except of the marsupial kind.

Two other genera, furnished with a scutellum or a sutural hiatus, with the anterior legs often deprived of or unprovided with tarsi, and frequently long, slender, and curved in the males, are distinguished from all other Co-

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[1] *Règne Animal*, t. iv. p. 531.

[2] Probably from α priv. and τευχος, *an instrument of war*, the head being unarmed.

[3] The genus Scarabæus of Macleay (Ateuchus of most modern authors) is proper to the ancient world. Of the forty-three species which compose its five types, as exposed in the *Horæ Entomologicæ*, twenty-seven occur in Africa. The first type extends from the Atlantic Ocean to Thibet, and from Austria to the Cape of Good Hope. It contains the following species:—*S.* (Heliocantharus) *sacer*, *Dufresnii*, *pius*, *Bonelli*, *Hottentotus*, *impius*, *Lamarckii*, *Cuvieri*, *Sanctus*, *Palæmon*, *intricatus*, *puncticollis*, *Spencii*, *Degeeri*, *Savignii*, *morbillosus*, *laticollis*, *variolosus*, *semipunctatus*. Type second contains as yet only a single species, from the north of Africa, *S.* (Mnematium) *Ritchii*. The third type seems confined to the south of Africa, and includes *S.* (Pachysoma) *Æsculapius* and *Hippocrates*. The existence of the fourth type is inferred upon general principles, and from an observed hiatus in the series of affinities, but has not yet been specially detected. The fifth type inhabits all that tract of country which extends from the Atlantic Ocean to the Chinese Sea, and from Paris to the Cape of Good Hope, and contains *S.* (Gymnopleurus) *azureus*, *nitens*, *mundus*, *sinuatus*, *pilularius*, *Sturmii*, *atronitidus*, *flagellatus*, *humanus*, *Leei*, *Bufo*, *fulgidus*, *cærulescens*, *affinis*, *cyaneus*, *Kœnigii*, *granulatus*, *parvus*, *miliaris*, *spilotus*, *maculosus*.

[4] *Description des Insectes recueillis par M. Caillaud*, forming part of his *Voyage en Nubie*.

[5] For the other genera, see *Règne Animal*, t. iv. p. 405. Consult also *Hor. Ent.* p. 494.

[6] From ονθος, *dung*, and φαγος, *eating*.

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prophagi by the form of the club of the antennæ; its first joint (or the seventh of the whole, counting from the base) being sub-triagonal, and receiving within it the ensuing, of which the inner margin is shaped like a horse-shoe; the third or terminal article is in the form of a reversed cupula. The thorax is large, and usually exhibits two depressions near the middle of its posterior margin. In ONITIS, Fab., the second article of the labial palpi is the largest of all; and the scutellum, though small and sunken, is yet visible. The anterior legs are generally long, slender, and curved in the males, and the tarsi are often absent. The thorax, with a few exceptions, is without horns. In PHANÆUS of Macleay (Copris, Onitis, Fab.), Plate CCXXXVII. fig. 4, the first article of the labial palpi is the largest, and dilated on the inner side. A simple sutural void indicates the place of the scutellum. This genus is composed of large and beautiful species, chiefly from the equinoctial regions of the new world. The males differ greatly from the females in regard to the horn-like processes which frequently characterize the head and thorax of the former; but the respective length of the legs does not differ between the sexes, as in the preceding genus.

The genus COPRIS[1] (Pl. CCXXXVII. fig. 5), as now restricted by Latreille, contains those species only the antennæ of which are terminated by a trifoliate club; the four anterior tibiæ strongly dilated and truncated at the extremity; both scutellum and hiatus wanting; the body thick, and differing on its upper surface in the sexes; and the labial palpi composed of three distinct joints, of which the first is the largest, almost cylindrical, and not dilated on the inner side. The largest species of this numerous genus (there are eighty-four in Dejean's collection, of which, however, scarcely half a dozen are European, and only one, *C. lunaris*, occurs in England) are indigenous to the warmer countries of Asia and Africa.[2] Many species are likewise native to the new world.

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In others the legs are inserted at equal distances from each other; the scutellum is distinct; the labial palpi smooth, or but slightly haired, with the third and terminal article larger, or at least longer, than the preceding.

In the genera of this subdivision of the Coprophagi the elytra entirely envelope the contour of the abdomen, to which they form as it were an arched covering,—a character by which they approach the ensuing section. They are, however, closely related, by the structure of their legs and antennæ, to the preceding genera; although the sexual differences are less pronounced or apparent, and frequently consist merely in small tubercles instead of horns. All the species are of small size, and some of them are among the most frequent of the British Lamellicornes. They constitute the family *Aphodiidæ* of the English entomologists. These insects are extensively distributed over the whole of the north temperate zone; and Mr Macleay has made out the proportion of tropical species to be to those from countries beyond the tropics as one to eight. According to the same authority, none have hitherto been brought from New Holland, although several occur at the Cape of Good Hope, which is nearly of the same south latitude. It is probable, however, that if the marine detritus of New Holland were properly searched, some insects at least approaching to *Psammodii* in habit would occur.[3]

Although these insects closely resemble each other in general structure, they yet differ rather widely in their modes of life. They are not all coprophagous, strictly speaking, for several prefer vegetable matter, for the most part marine, in a state of putrescence. We shall notice the two principal genera. In APHODIUS,[4] Fab. (Plate CCXXXVII. fig. 6), the last article of the maxillary palpi is cylindrical, and that of the labial more slender than the preceding. The maxillæ have no appendage, or corneous and dentated lobe, on the inner side. The species of this genus are slow of foot, but they fly with facility; and their appearance is interesting, as denoting the "ethereal mildness" of returning spring. They are common in cow pastures. We received the species figured on the plate referred to (*A. bipunctatus*) from the south of Russia. Above fifty species occur in Britain, and three times that number are known to naturalists. In *Psammodius*, Gyllenhal (so named from ψαμμωδης, sandy, in reference to the places of their most frequent occurrence), the last article of the palpi is almost oval, and longer and thicker than the others, and the internal lobe of the maxillæ is corneous, and divided into two dentations.

SECTION 2D, ARENICOLI.

The groups of this section have one character in common with the two genera last mentioned, that the elytra entirely cover the posterior extremity of the abdomen; but their other features are distinctive. The labrum is coriaceous, and generally projects beyond the epistoma. The mandibles are corneous, and usually curved and salient. The terminal lobe of the maxillæ is straight, and not curved inwards. The third and last article of the labial palpi is always very distinct, and always at least as long as the preceding. With few exceptions, the antennæ consist of from ten to eleven articulations. Like the preceding insects, however, these also live in dung, beneath which they dig holes in the earth. Their principal period of flight is during the evening, after sunset. When touched they counterfeit death.

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In this subdivision the labium is terminated by two lobes or projecting ligulæ; the mandibles are generally salient and curved; the labrum is exposed in whole or in part; the antennæ, in the greater number, are composed of eleven articulations. The body is black or reddish, with the elytra smooth or simply striated. The males are generally distinguished from the females by horn-like projections and other external characters. They affect more especially excrementitial substances.

In the genera ÆGIALIA of Lat. and CHIRON (Plate CCXXXVII. figs. 7, 11) of Macleay, the antennæ are only nine jointed. In the latter their terminal club is rather semipectinated than foliated, and the species are placed by some with *Passalus*.

In the subsequent genera the antennæ are considered to consist of eleven joints, although the computation varies according to the view which may be adopted of the exact structure of the articulations. The genus LETHRUS, Scopoli, is distinguished from all the others by the form of the antennal club, like a reversed cone, and composed of leaflets contorted into a kind of funnel, and fitted concentrically into each other; and by the mandibles,

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[1] From κοπρος, *dung*.

[2] The fine insect which, following the nomenclature of M. Fischer of Moscow (*Entomog. de la Russ.*), we have represented as an *Ateuchus*. (Plate CCXXXVII. fig. 8), is, we understand, regarded by Latreille as belonging to the genus *Copris*.

[3] *Hor. Ent.* i. p. 58.

[4] From αφοδος, *dung*.

which are entirely dentated and serrated on their inner side, and present a corneous advancement underneath, especially in the males. *L. cephalotes* is said to be extremely injurious to cultivated grounds, where it attacks the scarcely visible buds and leaves of plants, cutting them cleanly off with its mandibles. It is hence called *Schneider* in Hungary, where it sometimes proves very hurtful to the vines. This species (there are only two or three others known) lives in holes in the earth, and fierce battles take place during the nuptial season between the males when aspiring to the favour of the gentler sex. The antennal club of the remaining Arenicoli is composed of ordinary-shaped leaflets, placed one on another like the leaves of a book. In GEOTRUPES of Lat. (Plate CCXXXVII. figs. 9 and 10) named from γη, *the earth*, and τρυπαω, *to bore*, in reference to their excavating propensities, the club of the antennæ is oval or ovoid, and the edges of all the leaflets are perceptible even when the part is contracted. The labrum forms a transverse square, entire, or simply dentated. The mandibles are curved, greatly compressed, dentated at the extremity, and frequently sinuated on the inner side. The species are pretty numerous, and occur both in Europe and America. Some are common in Britain, especially *G. stercorarius*, a large black beetle, with brilliant metallic blue or purple reflections on the under surface, well known as "wheeling its drowsy flight" during fine evenings. We have often been amused by the different devices made use of by insects to deceive their enemies. While the Byrrhidæ, and several other tribes already alluded to, contract their limbs when alarmed, so as to give themselves the appearance of a little ball of inert matter in no way tempting to any insectivorous creature, the species above named pursues an opposite line of conduct, and sticks out its legs at full length, where it holds them perfectly still and rigid, so as to produce the same appearance as if it had been long deprived of life. It is thus supposed to deceive the cunning rook and other birds, which value it chiefly as a living prey.[1] In BULBOCERAS[2] of Kirby (Pl. CCXXXVII. figs. 12, 13, and 14), one of the mandibles is simple at the extremity, while the other is dentated. The genus is also distinguished from the preceding (in common with *Athyreus* and *Elephastomus* of Macleay) by having the club of the antennæ large, orbicular, or nearly globular, with its first and last leaflet, when the part is contracted, completely enveloping the tenth or intermediate, and forming for it a kind of box (see figs. 13 and 14).

In *Hybosorus* and *Acanthocerus* (placed in different families, the former in *Geotrupidæ*, the latter in *Trogidæ*, by Macleay[3]), the antennæ consist, as in most of the subsequent Scarabæides, of ten articulations.

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In this our second subdivision of the ARENICOLI, the antennæ, scarcely longer than the head, are composed of ten articulations, of which the first is large and hirsute. The ligula is entirely concealed by the mentum. The labrum and mandibles are but little exposed, and the latter are thick. The palpi are short, the mentum very hairy. The inner side of the maxillæ is armed with teeth. The body, of a cinereous or earthy hue, is rough or tuberculated on the upper surface. The head is inclined, and terminates in an angle or point. The thorax is short, transversal, without lateral borders, sinuated posteriorly, with the anterior angles advanced. The abdomen is large, arched, and covered with very hard elytra. The anterior legs are advanced, and their thighs cover as it were the lower surface of the head.

These insects form the genus TROX[4] of Fabricius and Olivier. They generally occur on sandy soils, and are supposed by Latreille to feed on the roots of plants. We suspect that our knowledge is still extremely vague regarding their habits of life and modes of transformation. It is certain that they are attracted by dried bones and other cadaverous remains, but it is difficult to determine whether this is owing to the peculiar colour, or the nature of the animal substance. Pallas observes, "sub cadaveribus æstivo ardore exsiccatis cum Histeribus et Dermestibus hospitatur;" but it by no means follows from that peculiarity of position that the insect partakes of the carcass, any more than that numerous other species which seek the secure covering of a rock or mass of stone, are in the habit of devouring these inorganic matters. We may further remark that the Troges are the only petalocerous insects among which we find an apterous species,—the *T. horridus* being destitute of wings. It forms the genus *Phoberus* of Macleay, and is worthy of consideration as probably destined, when its habits are better known, to throw some light, either by agreement or opposition, on the history of its congeners, and the value of the groups into which they have been divided. These in general are supposed to delight in cadaverous substances: all insects intended to live on animal matter, partially distributed and collected in masses, are provided with wings, which convey them rapidly (with the joint guidance of the sense of smell), to those decaying objects which they instinctively desire; but the species above named being destitute of wings, a doubt naturally arises as to the probability of its feeding, like its congeners, on dried cadaverous matter. It has been stated as an illustration of this point, that the genera *Silpha*, *Hister*, *Dermestes*, and other necrophagous kinds, are winged, whilst *Pimelia*, *Brachycerus*, &c. which, like *T. horridus*, frequent sandy deserts, are apterous,—a formation supposed to accord with the fact that the particles of which their food is composed are so universally spread over these arid plains as to obviate the necessity of any rapid or extended change of place.[5]

SECTION 3D, XYLOPHILI,[6] Lat.

In these the scutellum is always distinct, and the elytra do not cover the posterior extremity of the abdomen. In several the hooks of the tarsi are unequal. The antennæ have always ten articulations, of which the last three form a foliated mass,—the central leaflet being never entirely concealed or inclosed by the others. The labrum is not projecting, and only its anterior part is exposed. The mandibles are entirely corneous, and laterally project beyond the head. The maxillæ are corneous, or of a solid texture, straight, and usually toothed The ligula is covered by an ovoid or triangular mentum, narrowed and truncated at the extremity, where the angles are frequently dilated. All the legs are inserted at equal distances from each other.

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A first subdivision contains those genera in which the males are distinguished from the females by tubercles or

1 *Ent. Edinensis*, p. 180.

2 From βολβος, *a bulb*, and κερας, *a horn*.

3 *Hor. Ent.* pp. 120 and 136.

4 Τρωξ, from τρωλῶ, *I gnaw*.

5 See *Horæ Ent.* p. 62; *Ent. Ed.* p. 186; and *Règne Animal*, t. iv. p. 546.

6 From Ξυλον, *wood*, and φιλος, *a lover*.

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horn-like projections on the head or thorax, and sometimes by a difference in the form of the latter part. The epistoma is small, triangular, and either pointed, truncated, or bidentated at the end. The labrum is almost always concealed. In some the maxillæ terminate by a simple coriaceous or crustaceous lobe, more or less hairy, and without teeth: in others they are entirely squamous or scaly, pointed, and provided with a small number of teeth, accompanied by hairs. The mentum is ovoid, or truncate-triangular. The chest exhibits no projection. The hooks of the tarsi are generally equal. The scutellum is small, or of medium size. The colours incline to black and brown.

Of those genera in which the maxillæ are terminated by a coriaceous or crustaceous lobe without teeth, and simply hirsute or furnished with cilia, we shall adduce as an example Oryctes[1] of Illiger (Pl. CCXXXVII. fig. 15). The legs of these differ but little in length, and the four posterior tibiæ are thick, strongly incised or emarginate, with an extremity greatly widened, and appearing as if stellated in some. This genus contains some large and striking species, such as *O. rhinoceros*, and others, from the East Indies. There are few European species, and of these *O. nasicornis* is by some regarded as indigenous in England. It feeds on tan and rich vegetable mould. Its larva is well known as having furnished the great Swammerdam with the subject of one of his many remarkable anatomical investigations.

Of such as possess maxillæ which are usually corneous or scaly, and more or less dentated, we shall mention the genus Scarabæus[2] properly so called (Pl. CCXXXVII. fig. 17). In these the body is thick and convex, and the external side of their mandibles sinuous or dentated. These insects occur chiefly in the equatorial regions, both of the old world and the new. They are scarcely known in Europe, and do not exist in Britain. *S. punctatus* is found in Italy and the south of France, and *S. monodon* in Hungary. Several species from South America (such as *S. Hercules*) and the East Indies, are remarkable for their gigantic size and extraordinary structure. *S. Atlas*, Fab. (*Hector* of Dejean?), is a native of Java, but it also occurs in the mainland.[3] We know little of the actual history or transformations of these fine insects, but their habits may be inferred to resemble those of *Oryctes*, and other congenerous tribes of the Scarabæides. The larvæ probably dwell in the decaying portions of great timber trees, and no doubt hasten the death and overthrow of these sylvan monarchs. We could dilate with pleasure on the singular aspect of these gigantic Coleoptera, did not the nature of our general plan, and our desire to notice, however briefly, most of the principal genera, preclude our entering into the descriptive details of species. We must therefore rest satisfied with a general reference to the works of Olivier, Fabricius, Latreille, Macleay, and the Catalogue of Dejean, part ii. p. 150.[4] We cannot help, however, here alluding to that principle of association in the human mind, by which size or dimension affects us with such different ideas in relation to different objects. Many may smile at our using the expression "gigantic" or "magnificent" to creatures the largest of which (of the Coleopterous kinds, e. g. *Prionus gigas*) scarcely exceeds six inches in length;—yet true it is, that to an entomologist accustomed only to the European forms of insect life, the first sight of any of the greater Prionidæ, or of *Scarabæus Hercules*, or *Atlas*, or *Actæon*, creates a feeling bordering upon awe, such as that which an enlightened artist may be supposed to experience on first beholding the perfect proportions of some great temple. Our ideas are perhaps equally relative in all departments both of art and nature. An Egyptian pyramid is thought *stupendous*, while North Berwick Law (of about equal height with the greatest of the Coptic monuments) is almost nameless as a Scottish mountain. An eagle, from his size and strength, is called a "feathered king," although his body is less than that of a pig a few months old. A mastiff or Newfoundland dog, being among the largest of the canine kind, is called "majestic," although a sucking elephant might squeeze both of them to death by an accidental stumble,—the said elephant being at the same time regarded as a "poor creature," because it is not a full grown example of the "wisest of beasts." An ancient walrus, floating among the hoary icebergs of the arctic seas, is looked upon as one of the most ponderous of created things; yet a Greenland seaman considers as insignificant, and will scarcely throw his harpoon into the sides of a young whale, which with one blow of its upraised tail could lash the ocean into foam, sink a "captain's gig," and send the walrus with a fractured skull to the bottom of the sea. The same principle is capable of illustration, by the practice of the more enthusiastic disciples of Isaac Walton. Even the most experienced of anglers gazes with delight, almost with wonder, at a river trout of three or four pounds weight. A grilse of the same dimensions, when made to "spurn the indignant shore," is viewed by the salmon fisher almost with a feeling of disappointment. We remember our friend Sir William Jardine killing, *inter alia*, one morning in the Tweed, a salmon of six and thirty pounds weight, in an hour and five minutes, and yet the same skilful angler was greatly astonished by a Loch Awe trout, which, though a giant of its kind, was, when brought to the balance, found wanting by several ounces, in the weight of twelve pounds. But to return to our beetles.

The genus Phileurus of Lat. (*Geotrupes* of Fabricius) differ from the Scarabæi in their mandibles, which are straighter, without sinus or dentation on the outer side;

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[1] *Ὀρυκτὴς, one who digs.*

[2] The term *Scarabæus* appears to have been either applied by the Romans to coleopterous insects in general, or at least to have been used with a wide and indefinite generic application. The origin of the word is by no means clear, and its derivation from *σκάπτω*, as given by Fabricius and Olivier, has been regarded as inconsistent with the rules of etymology. Mr Macleay thinks it difficult to obtain the word at all from the Greek, and regards it rather as being of Etruscan origin, the more especially as it never occurs in other than ancient *Latin* authors. Let us here note that the *Scarabæi* (properly so called) of Latreille belong to the genus *Dynastes* of Macleay, which includes the "giants of the insect race." We believe, however, that some *Prionidæ* exceed them in size.

[3] The specimen in our collection was *taken at Rangoon* by Sir Archibald Campbell, and obligingly transmitted to us by George Swinton, Esq. We have since received Javanese specimens from Lieutenant Loudon, R. N. of Musselburgh.

[4] Few points are more puzzling, or productive of greater delay in the progress of the student, than the cloud of synonyms by which natural history is overshadowed. This arises partly from ignorance, and partly from the (nearly allied) source of self-conceit, which induce together "confusion worse confounded," in the very face of an expressed desire to enlighten and amend. Even the great masters of the art have sometimes erred in the imposition of their generic names. The reader will bear in mind that *Geotrupes* of Fab. forms no part of the *Geotrupides* of the present day, but corresponds to the genus *Scarabæus* of Latreille; while the genus which bears the latter name in the *Horæ Entomologicæ* is identical in its prevailing parts to the genus *Ateuchus* of the *Systema Eleutheratorum.* There is no doubt that Mr Macleay's genus contains the insects to which the name of Scarabæus was applied by Pliny.

their body is also depressed, and the thorax dilated or rounded laterally. Such are *S. dydimus, vulgus, depressus*, of Fab.

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A second subdivision of the Xylophili contains those genera in which the head and thorax are of similar structure in both sexes, and not characterized by peculiar projections. The anterior margin of the labrum is almost always exposed or apparent. The maxillæ are entirely squamous, as if truncated at the termination, and furnished with five or six strong teeth on their inner edge. The mentum is proportionally shorter and broader than that of the Scarabæi, and less narrowed superiorly. The mesosternum is frequently prolonged to a horn or blunt point between or beyond the second pair of legs. The scutellum is usually large. The hooks of the tarsi are generally unequal. A small number excepted, these xylophilous Coleoptera are peculiar to the equatorial regions of the new world. They resemble in many respects our preceding subjects, and are at the same time nearly allied to the Melolonthæ, and particularly the Cetoniæ, of which they bear the external aspect, although their masticating organs differ. Fabricius and Olivier, in fact, arranged most of these insects with each other. The body of the kinds now under consideration is shorter, more rounded, and smoother than that of the preceding. They moreover differ in being frequently ornamented with brilliant colours.

In some (agreeing in this character with all the preceding Scarabæides), we do not perceive, between the posterior angles of the thorax and the exterior ones of the base of the elytra, an axillary piece filling up as it were the space comprised between these parts.

We shall first notice a genus in which the central portion of the chest presents no pointed prolongation. Such is Hexodon[1] (Pl. CCXXXVII. figs. 16, 20, 22, and 23), of which the body is almost orbicular, plane beneath; the head square, and received into a deep emargination of the thorax; the exterior margin of the elytra dilated and anteriorly marked by a small groove or gutter; the legs slender, and the hooks of the tarsi small and equal. But in the following genera the sternum is prolonged between the second pair of legs to a conical point. In Chrysophora of Dejean (*Melolontha chrysochlora*,[2] Lat.), Plate CCXXXVII. figs. 18 and 19, the hind legs of the male are very large, the thighs thick, the tibiæ arcuated, and terminated at the inner angle by a very strong point. Here is also placed the *Scarabæus macropus* of Shaw.[3] In Rutela, Lat. (Pl. CCXXXVII. fig. 25), there is no remarkable difference in the size of the legs in the two sexes; the mentum is almost isometrical; the scutellum small or moderate; and the sternal point is short,—not reaching to the origin of the two anterior feet. The body is ovoid or oval. Macraspis, Macleay (Pl. CCXXXVII. fig. 26), differs from the preceding in the proportions of the mentum, which is obviously longer than broad; in the short and rounded form of the body; in the length of the scutellum, which at least equals a third of that of the elytra; and in the length of the sternal point, the extremity of which attains to the origin of the two anterior legs, or extends beyond it. The mandibles are almost triangular, with the extremity pointed or emarginate. The maxillæ are furnished with several teeth. One of the hooks of the tarsi, at least of the four anterior ones, is bifid, the other entire. Here Latreille places also the genus Chasmodia of Macleay.

In other genera we perceive the axillary piece, before alluded to (agreeing with that seen in the same quarter in the Cetonia, and named *epimera* by M. Audouin[4]), filling up the space comprised between the posterior angles of the thorax and the exterior angles of the base of the elytra. Such is the genus Ometis of Latreille.

Section 4th, Phyllophagi.[5]

This section, as well as the ensuing, is formed from the great genus *Melolontha* of Fabricius, of which certain species are scattered also among the preceding groups. The Phyllophagi are nearly related to the concluding genera of the third section. Their mandibles, however, are covered above by the epistoma, and concealed beneath by the maxillæ,—their exterior side being alone exposed, but without either protruding or presenting the sinuosities or dentations observed in the Rutelæ and other analogous genera. The anterior edge of the labrum is exposed, and is sometimes of the form of a broad reversed triangle, sometimes (and more frequently) of a transverse lamina, emarginate in the centre. The number of the articulations of the antennæ is by no means uniform, and varies from eight to ten. The same observation applies to those of the club, which in several differs even in the sexes of the same species. The ligula is entirely covered by the mentum, or incorporated with its anterior face, and the elytra meet completely along the whole of the dorsal suture,—characters which distinguish our present species from those of the fifth or ensuing section.

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The family of Anaplognathides of Mr Macleay, and some other genera nearly allied to the preceding, form the first subdivision according to M. Latreille's views. The epistoma is thickened anteriorly, and forms, either alone or with the labrum, a vertical facette in the form of a reversed triangle, the point of which rests on the mentum. This last-named portion is sometimes almost ovoid, densely pilose, with the extremity either rounded or truncated, and without emargination,—sometimes in the form of a transverse square, with the middle of the superior margin prolonged into a tooth, simple or emarginate. The maxillæ of some terminate by a coriaceous or membranous lobe, very hairy, without teeth, or with a very small number, and situate near the middle of the internal border;—those of the others are entirely corneous, resemble mandibles, and are either truncated or obtuse and entire at the end, or terminated by two or three teeth.

In the genera Pachypus of Dejean, and Amblyteres of Macleay, the mentum is almost ovoid; and in the former the antennæ of the males are composed of only eight joints, of which the last five form the club,—in the latter they consist of ten joints, of which the last three form the club.

In the other genera of this subdivision the mentum forms a transverse square, the centre of the superior margin projecting in the manner of a tooth, entire or emarginate. In the genus Anaplognathus of Leach (peculiar to Australasia) there is a sternal projection, and the hooks of the tarsi are entire and unequal. The antennæ are composed of ten joints, and the extremity of the maxillæ is truncated, or obtuse and entire. These insects are

[1] From ἕξ, *six*, ὀδους, *tooth*, in allusion to the amount of dentations of the maxillæ. See Plate CCXXXVII. fig. 16.
[2] *Voyage de MM. Humboldt et Bonpland*, ii. xv. 1, fem.; 2, male.
[3] *Naturalist's Miscellany*, 380, iv.
[4] *Memoire sur le Thorax des Insectes.*
[5] From φυλλον, *a leaf*, and φαγος, *eating*.

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of considerable size, and of rather brilliant aspect.[1] Here also are placed the genera LEUCOTHYREUS of Macleay, and APOGONIA and GENIATES of Kirby.

* *

A second subdivision of the *Phyllophagi*[2] of Latreille contains the MELOLONTHIDÆ of Macleay. In these the labrum is in the form of a transverse plate or leaflet, generally strongly emarginate beneath in its centre, so that when seen in front it exhibits the figure of a reversed or demi-truncated heart. The mentum is as long if not longer than broad, somewhat narrowed anterior to the summit, and either nearly square or heart-shaped; its superior margin is straight, or more or less emarginate or concave, in the middle, but without any tooth-like dilatation. The maxillæ are usually squamous, and armed with several (frequently five or six) teeth. This subdivision is itself capable of a further partition into two groups, the first corresponding to the genus *Melolontha* of Fabricius, as restricted by Illiger and Latreille—the other to the genus *Hoplia* of Illiger. The former continues to bear the name of

MELOLONTHIDES.

Distinguishable by the following general characteristics. The number of complete leaflets of the club exceeds three in several genera. The form of the body is usually thick and massive. The mandibles are strong, entirely or in greater part corneous, and exhibiting at most only a membranous and hirsute appendage, placed in the emargination of the inner side; the superior extremity is strongly truncated, with two or three teeth or angular projections. All the tarsi are terminated by two hooks; the first article of the two anterior being prolonged inferiorly into a hooked appendage. The labrum is usually apparent,—the maxillary teeth robust.

The insects of which this group is composed were included by Linnæus, like all those with which we have been lately engaged, in his extensive genus *Scarabæus*, and they also continued to form a portion of that genus in the works of Geoffroy, Degeer, Schæffer, and other entomologists prior to the time of Fabricius. The last-named author established the genus *Melolontha*, which in its extended signification may be regarded as synonymous with the Melolonthides of Latreille. Were we to follow the prevailing and praiseworthy example of botanists, who bestow upon a *family* the name of the *genus* by which it is most strongly characterized, our present group ought to be denominated *Sericides*, in as far as the type is not formed by *Melolontha vulgaris*, but rather by *M. brunnea* of Fabricius, which now constitutes the genus *Serica* of Macleay. But as it is at all times desirable that families should be named after well-known genera, the designation now adopted is preferable to that which might be derived from the less noted though more characteristic type. The Melolonthides are not often distinguished by brilliant or metallic colouring Their elytra, of which brown is a characteristic colour, are generally slightly scaly or hirsute. Throughout the entire period of their existence these insects live on vegetable substances, and their ravages are often extremely injurious. The larvæ are very long lived, and sometimes pass three or four years in that destructive state. In cold and temperate climates they are very sluggish, if not torpid, during winter, and descend somewhat deeper into the earth to avoid the effects of frost. The perfect insects feed on leaves,—the larvæ for the most part on roots.

In the genus MELOLONTHA properly so called (from μηλεα, *an apple-tree*, and ἄνθησις, *inflorescence*[3]), see Plate CCXXXVII. fig. 29, the antennæ are ten-jointed, with the five or seven terminal joints in the males, and the six or four in the females, composing the club. The labrum is thick and strongly emarginate beneath. All the hooks of the tarsi are equal, and terminate in a point entire or simply uni-dentate at their base. The posterior extremity of the abdomen usually ends in a point or style, at least in the males. Of the species of which the antennal club in the male consists of seven leaflets, in the female of only six, we shall here notice the common cockchafer, *M. vulgaris* (*S. Melolontha*, Linn.). The body of this insect is of a pitchy black, with a whitish pubescence; the sides of the abdomen are marked by a range of triangular spots. The elytra are testaceous. The antennæ of the males are much larger than those of the females. (Plate CCXXXVII. figs. 21 and 24.) This, though a most abundant insect in England, and over most parts of Europe, is less generally known in Scotland, and is rare in the Edinburgh district. Specimens, however, have been procured in the park of Dalkeith House, in Lanarkshire, at Lorn in Ayrshire,[4] at Raehills and Moffat in Dumfriesshire, and as far north as Glencoe.[5]

We may observe that the existence in the perfect state of the species above named is of very short duration. The life of an individual is supposed not to extend beyond a week, and the entire species during each successive season prevails only for the space of a single month. The male speedily perishes after the sexual union, and the female merely survives for a sufficient time to deposit her eggs in safety. As soon as the latter is fecundated, she digs a hole in the earth of about half a foot in depth, by means of her dentated fore legs. The larvæ which proceed from these eggs are soft, lengthened, of a dingy-white or yellowish colour; they have six short scaly feet, a large scaly head, two antennæ, each composed of five pieces, and nine stigmata on each side of the body. The eyes are not at first visible—being concealed under the skin, which is ere long cast off. These destructive creatures feed upon the roots of various plants. They are most voracious during the summer season. In the course of the autumn they descend into the earth, and pass the winter in a state of profound repose, neither requiring nor desiring food. As

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[1] See *Hor. Ent.* p. 143; and *Linn. Trans.* vol. xii. pp. 401–5; also Leach's *Zoological Miscellany*, vol. ii. p. 44.

[2] Misnamed (we presume accidentally) *Xylophiles* in the second edition of the *Règne Animal*, t. iv. p. 558.

[3] Μηλολονθη, or Μηλανθη, is a term of frequent occurrence in Aristotle and other ancient authors, and was first applied by Fabricius to the insects of the present genus. It is derived from the words mentioned above, because the insects it denoted either were supposed to be produced from the flowers of fruit-trees, or were accustomed to resort to them for food. This circumstance renders it probable that the μηλολονθη of the ancients belonged to the family Cetoniides, as the true Melolonthides are hardly ever seen on flowers; and the description of Eustathius, who says that the animal resembled a wasp, led Mr Macleay to conjecture that it might be the *Trichius fasciatus*, a vernal beetle common in Greece, which might be readily mistaken by a casual observer for one of the Hymenoptera, as it bears a considerable resemblance to some of the members of that order, both in its colouring and mode of flight. Mouffet's investigations led him to a very different conclusion—that the insect was of a metallic green, and referable to the *Buprestides*. The former opinion is greatly the more probable, and accords with the brief notices on the subject found in ancient writers, particularly Hesychius and the scholiast on Aristophanes; but these notices are too imperfect to warrant the determinate application of a word obviously used with considerable latitude of meaning, and intended in all probability to indicate a group or tribe of insects rather than any individual species. (See *Hor. Ent.* p. 78; and Mouffeti, *Theat. Insect.* xxi. 158.)

[4] Professor Rennie, in *Insect Transformations*, 225.

[5] *Ent. Ed.* p. 188.

soon as the solar rays produce their genial influence in early spring, they ascend within six inches of the surface, and recommence their ravages. They change their skin every year, assume the nympha state in the course of the third autumn after they are hatched, and appear in the perfect state during the ensuing spring or early portion of summer. The beetle, when it first escapes from its cocoon, is pale and soft, and does not venture to leave its subterranean chamber for some time. But ere long it acquires a firm consistence, and crawling to the surface, it expands its wings, and mounting into the air, is henceforward no more a subterranean dweller, but seeks its nourishment among the umbrageous branches of the loftiest trees.[1]

Although the generality of insects are more destructive in the larva than in any other state, great ravages are occasionally committed even by the perfect insect. It is in relation to the present species that Mouffet records the number of beetles which at one time fell into the Severn as being sufficient to stop the wheels of the water-mills. In the year 1688 they covered the hedges and trees in a district of the county of Galway, in such infinite numbers as to hang in clusters like bees when they swarm. When on the wing they almost darkened the light of day, and produced a peculiar sound by the rustling of their wings. When feeding, the noise of their jaws might have been mistaken for the sawing of timber; and in a very short time the foilage of the trees for miles around was so totally consumed, that at midsummer the country wore the aspect of the leafless winter.[2] " One of the worst of these ravagers," say Messrs Kirby and Spence, " is the grub of the common cockchafer. This insect, which is found to remain in the larva state for four years, sometimes destroys whole acres of grass, as I can aver from my own observation. It undermines the richest meadows, and so loosens the turf that it will roll up as if cut with a turfing spade. These grubs did so much injury about seventy years ago to a poor farmer near Norwich, that the court of that city, out of compassion, allowed him L.25, and the man and his servant declared that he had gathered eighty bushels of the beetle.[3] In the year 1785 many provinces of France were so ravaged by them that a premium was offered by the government for the best mode of destroying them. They do not confine themselves to grass, but eat also the roots of corn; and it is to feast upon this grub more particularly that the rooks follow the plow.[4]"

The scarcity of this species in Scotland saves it from the fate often inflicted in the south, where *spinning a cockchafer* is a favourite amusement among school-boys. When the larger Coleoptera fall upon their backs, they have some difficulty in resuming their natural position,—and in Sweden, according to Sparmann, there is a fond belief among the simpler of the common people, that their sins will be forgiven them if they set a cockchafer upon its legs. If this creed be true, our English youths have much to answer for.[5]

The only other species of the genus which we shall mention is *M. fullo* (Pl. CCXXXVII. fig. 29), one of the largest of the European Coleoptera. It is sometimes nearly an inch and three quarters long, of a brown or blackish colour, marked with many irregular white spots. The club of the antennæ in the males is remarkably large. This species occurs chiefly on downs along the maritime shores of Europe. It is sometimes captured in England. We have received it from Persia and other eastern countries.

In the genus Rhisostrogus of Lat. (formerly Amphimalla of the same author), the species closely resemble the preceding; but the antennæ, consisting of nine or ten joints, have only three leaflets in the club. Such is a well known English insect not yet ascertained to inhabit Scotland, *R. Solstitialis*. In the genus Areoda of Leach and Macleay (Pl. CCXXXVII. fig. 30) the antennæ have ten articulations, the sternum is corneous, and all the hooks of the tarsi are equal in those individuals presumed to be females, and unequal in such as are regarded as males. The species are brilliantly adorned, and inhabit Brazil. All the preceding phyllophagous genera, it may be observed, with few exceptions, are furnished with ten articulations to the antennæ; but in the following Melolonthides there are only nine. In Phyllopertha of Kirby (from φυλλον, a *leaf*, and περθω, *to destroy*), the antennæ are only nine jointed. Here we place a species which often appears in prodigious quantities among ferns on commons in many parts of Britain. It is called the Bracken-clock in the north of England—*P. horticola*. It falls into the genus *Anisoplia* of Megerle and Dejean. A larger and much rarer species is *P. Frischii*. It has been found near Montrose. In the genus Serica[6] of Macleay (Pl. CCXXXVII. figs. 27 and 28), the joints of the antennæ seem to have been differently computed.[7] All the hooks of the tarsi are bifid. The body is ovoid, arched, with a silky aspect, and changeable reflections. Certain insects, as yet found only in New Holland, form the genus Diphucephala[8] of Dejean. Their tarsi are bifid, as in the preceding, but the body is narrow and elongated, and the thorax square. In Euchlora of Macleay (Plate CCXXXVIII. figs. 1, 2), the hooks of the tarsi are unequal, and there is no sternal projection; one of the hooks of the four anterior tarsi is bifid in the males, the body is arched, the epistoma short and transverse.

The second group of this subdivision, or the third and last of the Phyllophagi, is called

Hoplides,

and is characterized as follows. The mandibles are small and depressed, and as if divided longitudinally into two parts, of which the internal is membranous, the external corneous; the superior extremity presents no sensible dentations. The labrum is concealed or but slightly apparent. The maxillæ have frequently only small dentations. The body is short, depressed, broad, with the ely-

[1] Some very laborious and beautifully elaborated works have been recently published on the anatomical structure of the Melolonthæ. See more particularly *Considérations générales sur l'Anatomie comparée des Animaux articulés, auxquelles on a joint l'anatomie descriptive du Hanneton*, par M. Straus, 1 vol. in 4to, with plates. Paris, 1828. The illustrious and lamented Cuvier has observed of this production, that it is the only work fit to be compared to that of Lyonnet, *Sur la Chenille du Saule*. M. Dufour has also explained the digestive system of these insects, in the 3d vol. of the *Ann. des Sciences Nat.*; while the muscular economy of the wings and thorax has been described and figured by the accurate Chabrier, in his *Essai sur le Vol des Insectes*. Paris, 1823.

[2] *Phil. Trans.* xix.

[3] *Phil. Trans.* 1741, 581.

[4] *Introd. to Ent.* vol. i. p. 177.

[5] We may here record that the *Melolontha hippocastani*, Fab. (Olivier, i. 3, a, b, c) was taken by the writer of this article some years ago on the banks of Windermere. It was formerly confounded with *M. vulgaris*, but is distinguished by being rather smaller, shorter, and more convex; the elytra are narrowly margined with black, and the terminal style of the abdomen is rather shorter, and has a slight constriction or neck, which makes the extremity appear broader and more obtuse. It does not seem to be known as British to the English collectors. (See *Entomologia Edinensis*, p. 190, note.)

[6] From σηρικον, *silk*.

[7] Antennæ articulis decem, *Hor. Ent.* 146. Je n'en compte que neuf, *Règne Animal*, iv. 562.

[8] From διφυης, *double*, and κεφαλη, *head*.

tra narrowed posteriorly at the exterior side. The last two tarsi are usually furnished with but a single hook. In such as have two hooks to all the tarsi (genus *Dicrania*), the first joint of the anterior tarsi is prolonged inferiorly, and exhibits on the internal side a strong hooked tooth.

M. Leon Dufour, as Latreille informs us, has remarked, that the digestive canal in these insects (at least in such *Hopliæ* as he has examined) is much shorter than that of the Melolonthæ, and rather approaches the same part in the genus Cetonia. The chylific ventricle is smooth and flexuous. The small intestine is shorter than in Melolontha, and often presents an ovoid inflation at its origin. The great intestine is elongated, and destitute of valvular anfractuosities, and the rectum is distinctly marked by an obvious collar. The generative system resembles that of the Melolonthæ.

In the genus Dicrania (Lepel. and Serville, in *Encyclop. Meth.*), besides the characters alluded to above, the body is very smooth, without scales, the scutellum rather large, and there are two strong spines at the extremity of the four posterior tibiæ; the lower extremity of the two hindmost tibiæ is dilated. These insects are natives of Brazil. In the genus Hoplia of Illiger there is only a single hook to the two posterior tarsi (Plate CCXXXVIII. fig. 4). The pairs of the others are bifid and unequal. The extremity of the intermediate and hind tibiæ is as it were crowned by little spines of nearly equal length. The body is generally furnished with minute scales. The epistoma is either almost square or nearly semicircular. The thighs of the two hind legs are moderately enlarged, and the tibiæ are long, straight, and without a hooked tooth at their extremity. *H. farinosa* (Pl. CCXXXVIII. fig. 3), one of the most beautiful of European Coleoptera, is a common insect in the south of France. The antennæ are nine-jointed, the body is covered with silvery scales, of a pale but bright and ethereal blue, with a greenish or golden tint beneath. This species, on which a British entomologist gazes with great delight, is common in several European countries, near the banks of brooks and rivers.

Section 5th, Anthobii.[1]

The scarabideous insects of this section also formed a portion of the undivided genus Melolontha, and are nearly allied to the concluding members of the preceding groups. Their paraglossæ, however, or divisions of the ligula, project beyond the upper extremity of the mentum, and the edges of the elytra are somewhat open, or removed from the usual line of the dorsal suture, towards their posterior extremity, which is narrowed to a point, or rounded. The antennæ consist of from nine to ten joints, of which the three last alone form the club in both sexes. The terminal lobe of the maxillæ is often almost membranous, silky, in the form of a pencil,—in others it is coriaceous and dentated along the inner edge. The labrum and mandibles are more or less solid, according as these parts are exposed or covered. These insects live among flowers and the varied foliage of shrubs and trees.

In the genus Amphicoma,[2] Lat. (Pl. CCXXXVIII. figs. 5, 6) the first joint of the antennal club is concave, and encases the others. The mandibles are rounded and curved on the exterior side, without dentation on the inner margin; the antennal mass is globular, the abdomen soft, and all the legs of ordinary size. The epistoma is distinctly margined. The anterior tibiæ have three teeth on their outer edge. The first four articles of the tarsi are strongly ciliated in the males. These singular insects can scarcely be regarded as European, although they do occur occasionally in Greece. They are more frequent in the south of Russia, and in the western parts of the Persian dominions. Comte Dejean informs us that *A. hirta*, Fab. is the female of *A. vulpes* of the same author. *A. vulpecula*, with which we were favoured by M. Faldermann of the Imperial Botanic Gardens of St Petersburg, appears to be also a variety of the first-named insect. The only other genus of this section which we can here notice is Anisonyx of Lat., an example of which is given in Plate CCXXXVIII. figs. 7 and 13.

Section 6th, Melitophili.[3]

In these the body is depressed, usually oval, brilliant, hornless, with the thorax trapeziform or almost orbicular. An axillary piece occupies, in the greater number, the space comprised between the posterior angles and the exterior of the base of the elytra. The anal termination is exposed. The sternum is frequently prolonged in the form of a point or advanced horn. The hooks of the tarsi are equal and simple. The antennæ are 10-articulate, with the last three joints forming the club, which is always foliaceous. The labrum and mandibles are concealed, lamelliform, and nearly if not entirely membranous. The maxillæ terminate in a silky lobe, in the form of a pencil, without corneous teeth. The mentum is usually ovoid, truncated superiorly, or almost square, with the middle of the superior edge more or less concave or emarginate. The ligula is not projecting.

The alimentary tube of these insects, according to M. Dufour, is shorter than in any of the scarabideous family. The chylific ventricle has usually its external tunic covered by very small superficial papillæ, or projecting points. The enlargement which terminates the small intestine is not cavernous, as in the Melolonthæ.[4] The larvæ are said to live in decayed wood. In the perfect state they occur on flowers, and not unfrequently also on the trunks of such trees as exude any fluid.

This section, according to the views of M. Latreille, by which we have already been so long guided, is susceptible of division into three principal groups, corresponding to the genera *Trichius* of Fabricius, *Goliathus* of Lamarck, and *Cetonia* of Fabricius, but reduced and simplified by certain abstractions.

The Melitophili of the first two divisions have no strongly-marked sternal projection; the lateral portion of the mesosternum (or that named *epimera* by M. Audouin) does not generally manifest itself upwardly. The thorax does not increase from before backwards as in Cetonia; nor is the exterior side of the elytra abruptly narrowed or uni-sinuate a little below the humeral angle, as in those insects. A more rigorous character consists in the labial palpi being inserted in lateral grooves of the anterior face of the mentum, so that they are entirely exposed, the sides of the mentum jutting beyond them at their origin, and protecting them behind. In the first two divisions these palpi are inserted beneath the lateral margin of the mentum, or in the margins themselves, in such manner

[1] From ανθος, *a flower*, and βιος, *life*.

[2] From αμφι, *about*, or *on both sides*, and κομη, *hair*, in allusion to the frequent covering with which the species are invested.

[3] From μελι, *honey*, or μελιτοω, *to make honey*, and φιλος, *a lover*.

[4] For other details, especially for such as illustrate the generative system, see *Annales des Sciences Nat.* t. iii. p. 235, and t iv. p. 178

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that the first articulations, when viewed from before, do not appear.

1st, Trichides.

In these the mentum is either almost isometrical, or rather longer than broad, and leaves the maxillæ exposed. They correspond, as we have said, to the genus Trichius of Fabricius (Pl. CCXXXVIII. figs. 8, 9), of which we may mention as an example *T. fasciatus*, probably the only British species. It is black, with scattered yellow hairs, the elytra yellowish, with three transverse black bands, interrupted at the suture. It is very rare in Scotland, but is, however, recorded by Mr Curtis as occurring "on the flowers of the thyme, near Loch Rannoch, in July." It was also noticed some years ago by Dr Greville in Glen Tilt, and we saw it taken by Mr Giles Munby, on the southern border of Sutherland, early in the month of August 1833. The dimensions of the female considerably exceed those of the male. The genus, as now restricted, is not very extensive. Dejean enumerates twelve species, several of which are from North America.

2d, Goliathides,

May be distinguished from the preceding by the mentum, which is much longer and wider, and covers the maxillæ. In some the mentum is concave in the centre. The anterior extremity of the epistoma is neither toothed nor horned. Such is the genus Cremastocheilus of Knock (Pl. CCXXXVIII. fig. 10), in which the thorax forms nearly a transverse square; the maxillæ are terminated by a strong tooth, hooked or falciform, with setæ or little spines in place of an inner lobe; the last article of the palpi is very long and cylindrical; the mentum in the form of a widened heart, or of a reversed triangle rounded at the upper angles, without sensible emargination. In others the mentum is in the form of a greatly widened heart, but without a discoidal cavity, its superior edge being emarginate or sinuous. The anterior extremity of the epistoma in the males is divided into two lobes, in the form of obtuse or truncated horns. The thorax is almost orbicular. Such is the extraordinary genus Goliathus of Lamarck (*Cetonia* of Fab. and Oliv.), Pl. CCXXXVIII. figs. 14 and 16, which contains some of the largest and most striking of coleopterous insects. One of the species which we have represented appears to exhibit some variation in its markings.[1] The same species seems figured by Drury (*Illustrations*, vol. i. pl. 31), who says it was brought from Africa, where it was found "floating dead in the river Gaboon, opposite Prince's Island, near the equinoctial line." The only specimen with which we are now acquainted is that preserved in the Hunterian Museum, Glasgow. Mr Kirby has described two smaller species from Brazil.[2] Other kinds form the genus Inca of modern writers.[3]

3d, Cetoniides.

In this group the sternum is more or less prolonged to an obtuse point, between the intermediate pair of legs; the axillary piece before mentioned is always visible above, and occupies the entire space which separates the posterior angles of the thorax from the base of the elytra; the thorax is usually enlarged posteriorly, and has the form of a triangle truncated anteriorly or at its point. The mentum is never transversal; its superior margin is more or less emarginate in the middle. The terminal lobe of the maxillæ is silky or pencil-shaped. The body is almost ovoid, and depressed. The membranaceous texture of the mandibles and maxillæ of these insects demonstrates, as Mr Macleay has observed, that in the perfect state they live on vegetable juices. Thus *C. morio*, Fab. and doubtless many others, especially of the darker coloured kinds, regale themselves on the sap of wounded trees,—while *C. aurata* and its brilliant allies are only found on flowers.[4] The Cetoniides, though in general gay and ornamental insects, yield in metallic splendour to several species of the genera *Rutela*, *Glaphyris*, and *Anaplognathus*. "Nothing, however, can exceed the beauty and lustre of the polish, or the admirable variety of ornament, with which their elytra are adorned. The larvæ live in the fattest vegetable soils; but notwithstanding the excellent observations of Degeer, much remains to be performed towards the elucidation of this part of their history."[5]

Sufficient data have not yet been collected for the proper elucidation of their geographical distribution, but it appears that many more species exist within than without the tropics. In some the thorax is prolonged posteriorly in an angular form, so that the scutellum disappears. These form the genus Gymnetis of Macleay (Plate CCXXXVIII. fig. 12). Several species occur in America. In others from New Holland and the East Indies the clypeus is bifid, or armed, in the males, with a couple of horns, and the body is proportionally narrow and elongated, with the abdomen obviously decreasing in size posteriorly. It is even almost triangular in some. The club of the antennæ is elongated. These constitute the genus Macronota of Wiedemann (Plate CCXXXVIII. fig. 15). "Mais toutes ces coupes n'acquerront de la solidité que lorsqu'on aura fait un étude particulière des nombreuses espèces du genre Cetonia de Fabricius."[6]

The European Cetoniæ are provided with a scutellum of ordinary size. *C. aurata* (commonly called the rose-beetle) is well known in many parts of England. It is nearly an inch long, of a brilliant golden green above, with coppery red reflections beneath, and some whitish markings on the elytra. It has been taken in Morayshire by the Misses Dick Lauder, and is also known to have occurred in Dumfriesshire. It is still, however, to be regarded as *inter rariores* of the Scottish species. Dejean's Catalogue contains 125 Cetoniæ, of which the greater part are foreign to Europe. They occur over all the warmer regions of the earth. Java produces several of great beauty, of which *C. Macleayi* is described, and figured by Mr Kirby in his *Century of Insects*.[7] The one which we have represented, *C. Baxii* (Plate CCXXXVIII. fig. 11), is highly prized by collectors.

Tribe 2d, Lucanides.

In this second tribe or principal division of the lamellicorn Coleoptera, which derives its name from the genus Lucanus of Linnæus, the club of the antennæ is composed of leaflets or dentations disposed perpendicularly to its

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[1] See Olivier, *Coléoptères*, No. 6, pl. 5, fig. 33, et pl. 9, fig. 33. We are indebted to Mr Joseph Dalton Hooker for an accurate drawing of the valuable specimen in the Glasgow Museum. We did not receive it till the figure above referred to had been copied by our engraver from Olivier's work.

[2] *Linn. Trans.* vol. xii. p. 407.

[3] *Encyclopédie Méthodique*, art. *Scarabeides*. See also Dejean's *Catalogue*, p. 168.

[4] *Hor. Ent.* p. 74.

[5] *Ibid.* p. 75.

[6] *Règne Animal*, t. iv. p. 574.

[7] *Linn. Trans.* vol. xii.

Coleoptera Pentamera.

axis, like the teeth of a comb. These organs always consist of ten joints, of which the first is usually much longer than the others. The mandibles are always corneous, generally projecting, and of larger size as well as of different form in the males. The maxillæ in most terminate in a narrow lobe, lengthened and silky; in others they are entirely corneous and dentated. The ligula in the greater number is formed of two small silky pencils, more or less projecting beyond the mentum, which is almost semicircular or square. The anterior legs are generally elongated, with the tibiæ dentated all along their outer edge. The tarsi are terminated by two hooks, equal, simple, with a small appendage, ending in two setæ, between them.[1] These insects compose two sections which correspond to the genera *Lucanus* and *Passalus* of Olivier.

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In the first the antennæ are greatly bent or geniculate, smooth, or but slightly hirsute; the labrum small, or confounded with the epistoma; the maxillæ terminated by a membranous or coriaceous lobe, very silky, pencil-shaped, without teeth, or with one at most; the ligula either entirely concealed, or incorporated with the mentum, or divided into two narrow elongated silky lobes, more or less projecting beyond the mentum. The scutellum is placed between the elytra.

In some genera the antennal club consists only of from three to four joints or leaflets. Such are SYNODENDRON[2] of Fab. (Pl. CCXXXVIII. fig. 20), ÆSALUS of Fab., LAMPRIMA of Lat. (ibid. figs. 17 and 22), RYSSONOTUS, Macleay (*Luc. nebulosus* of Kirby), PHILODOTUS, Macl. (ibid. fig. 19), and LUCANUS properly so called (ibid. fig. 18). To the last belongs *L. cervus* (Plate CCXXXIII. figs. 1, 2, 3), the largest and most formidable looking of the British Coleoptera. It inhabits the interior of oaks and beeches for several years before assuming its final transformation, and is by some regarded as the *Cossus* of the ancients, a vermiform larva, long regarded as a delicious food, but not now coveted by the refined epicures of modern days.[3] In other genera of this section the club of the antennæ, as in SYNDESUS of Macleay, is composed of the seven terminal articulations.[4]

* *

The Lucanides of the second section have the antennæ simply bent, or but slightly geniculate and hairy; the labrum is always exposed, crustaceous, and transversal; the mandibles strong and much dentated, but without any remarkable disproportion of size between the sexes; the maxillæ are entirely corneous, with two strong teeth at least; the ligula, likewise corneous or very hard, is placed in the superior emargination of the mentum, and terminated by three points. The abdomen is supported on a kind of pedicle, bearing the scutellum above it, and separated from the thorax by a neck or obvious interval. These insects form the genus PASSALUS of Fabricius (Plate CCXXXVIII. figs. 21 and 23), which has undergone subdivision in recent times. In PAXILLUS of Macleay, for example (fig. 23), the club of the antennæ is composed of five joints, the labrum is very short, the maxillæ have but two teeth, one terminal, the other on the inner side.[5] Mr Macleay restricts Passalus to such species as have only three articulations to the club of the antennæ, as shown by fig. 21. The last-named author here places the genus *Chiron*, which Latreille classes with the coprophagous tribe. All these insects are foreign to Europe, and we believe also to Africa. They are characteristic chiefly of South America, but are also known in New Holland, Java, and the eastern countries of Asia. Madame Merian informs us that the larva of the species figured in her work feeds on the roots of the sweet potato. The perfect insect is well known in sugar-houses.

Coleoptera Heteromera.

HETEROMERA.

Five Articulations to the first four Tarsi, and four to the hindmost pair.

All the groups of this, the second primary section of the coleopterous order, feed on vegetable substances. Latreille comprises them under four great families, of which the first two exhibit, by reason of an excrementitious apparatus discovered by M. Dufour, an analogy to some of the pentamerous Coleoptera. Their chylific ventricle is also frequently beset by papillæ. In several of these insects we find the vestiges of another secreting apparatus, of which we have few examples among the Coleoptera, that denominated the *salivary apparatus.* The hepatic vessels, as in the preceding or pentamerous section, with few exceptions, amount to six in number, and have two intestines, distant from each other; at one extremity, according to Dufour, they are inserted by six insulated ends around the collar which terminates the chylific ventricle; at the other they open into the origin of the cæcum by trunks varying in number in different families and genera.

The first general division of the section may be made to contain the first three families. The elytra are generally of a firm and hard consistence, the hooks of the tarsi almost always simple, the head ovoid or oval, susceptible of being sunk posteriorly in the thorax, or sometimes narrowed behind, but not abruptly, and without any neck at the base. Many of these insects are "darklings," that is, lucifugous or light-shunning.

FAMILY I.—MELASOMA.

This group consists of black or ash-coloured species, without mixture or variety of colour, from which circumstance they derive their name.[6] They are for the most part apterous, with the elytra as it were soldered together. The antennæ are partly or entirely granose, almost of the same size throughout, or a little enlarged at their extremity, inserted under the projecting margin of the head, with the third articulation generally elongated. The mandibles are bifid or emarginate at the extremity, and there is a corneous tooth or hook on the inner side of the maxillæ. All the articulations of the tarsi are entire, and the eyes are oblong and but slightly elevated—a character which, according to M. Marcel de Serres, indicates nocturnal habits. Almost all these insects dwell upon the ground, either in sandy soils or under stones, and they are not unfre-

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[1] See our elementary plate (CCXXXIII.) figs. 1, 2, and 3.

[2] From Σὺν, *with*, and Δενδρον, *wood.*

[3] As we have given figures on the plates above referred to, of most of the genera just named, we abstain from entering into the details of their respective characters.

[4] For a description of the singular genus CHIASOGNATHUS of Stephens, see the *Cambridge Philosophical Transactions* for 1831.

[5] The insect which we have figured under the name of *Passallus pentaphyllus*, is, we believe, synonymous with *Paxillus Leachii* of Macleay, *Hor. Ent.* p. 106.

[6] From *μέλας*, *black*, and *σῶμα*, *body.*

Coleoptera Heteromera.

quent in cellars, stables, the ground floors of houses, and other dark and sombre situations. According to M. Dufour,[1] the insertion of the biliary vessels takes place on the under surface of the cæcum, by means of a single tubular trunk resulting from the junction of two strong short branches, themselves composed of the reunion of three biliary vessels. The bile is yellow, sometimes brown, or even violet coloured. The alimentary tube[2] is long; in the first tribe, that of the Pimeliariæ, three times the length of the body. The œsophagus is long, and leads to a crop, smooth or glabrous externally, more developed among the last-named insects, where it forms an ovoid sac lodged in the pectus; it is furnished interiorly with folds or longitudinal fleshy columns, terminating in some species, such as *Erodii* and *Pimeliæ*, beside the chylific ventricle, at a valve formed of four principal corneous, oval, and connivent parts. The chylific ventricle is elongated, flexuous or doubled, generally beset with small papillæ or projecting points, and terminates in a small collar, callous within, which receives the first insertion of the biliary vessels. In the genera *Blaps* and *Asida* there is a salivary apparatus, consisting of two floating vessels or tubes, sometimes, as in the latter, perfectly simple, sometimes, as in the former, irregularly branched. The same structure no doubt will be found to occur in others of the family. The texture of the tunics of the alimentary canal has been studied with great care and assiduity by M. Marcel de Serres.[3] The adipose tissue is more abundant in these Heteromera than in the ensuing; and it is probably this provision which enables them, even when transfixed and fastened down by a pin, to live for six months without food—a fact witnessed (we presume accidentally) by Latreille in a species of *Akis*.

Our present family, which corresponds to the ancient unrestricted genus *Tenebrio* of the Linnæan system, is subdivided according to the absence or presence of the wings.

Tribe 1st, Pimeliariæ.[4]

Apterous, the elytra generally fixed or soldered. Palpi almost filiform, or terminated by an article not greatly dilated, and not forming a distinct triangular or securiform mass.

In the genus Pimelia properly so called,[5] the body is more or less ovoid and oval, with the thorax narrower even at the base than the abdomen, generally convex, without sharp prolongations at the posterior angles, or posterior projection at the præsternum. These insects are proper to the basin of the Mediterranean, to the western and southern parts of Asia, and to Africa.

In the three following genera the body is ovoid, short, arched or gibbous above, with the thorax short, as broad posteriorly as the base of the elytra, and terminated on each side by a sharp angle. The præsternum is dilated posteriorly in the manner of a lamina or point, with its posterior extremity resting on the mesosternum. In Erodius, Lat. the last two joints of the antennæ are united, and form a little button-shaped mass. The anterior tibiæ have a strong tooth near the middle of the exterior side, and another on the same side at the end. The mentum is incased (*encadré*) inferiorly, and covers the base of the maxillæ. *E. gibbus*, which is black, the elytra with thin raised lines, occurs in Portugal. In Zophosis,[6] Lat. the antennæ are almost filiform, or enlarge insensibly towards the end. The anterior tibiæ want the teeth. *Z. testudinarius* is black, the elytra chagrined, and covered on the sides with a whitish powder. It occurs at the Cabe. In Nyctelia, Lat. (Pl. CCXXXVIII. fig. 24), the third article of the antennæ is much larger than the preceding, and the following, as well as the ninth and tenth, are almost globular. The base of the maxillæ is exposed. The species are proper to South America.

In the genus Hegeter, Lat. the thorax assumes the form of a trapezium, almost as broad at the posterior margin as the base of the elytra, against which it is applied throughout its breadth. The terminal article of the antennæ is rather less than the preceding. In Tentyria of Lat. (*Akis*, Fab.) the thorax is almost orbicular, sometimes narrower than the abdomen, sometimes of the same breadth, but rounded at the posterior angles, and leaving an hiatus between them and the base of the elytra. The terminal article of the antennæ is as large as the preceding. These, as well as the following genera, are peculiar to the warm and western countries of the ancient continent.

The genus Akis[7] of Fab. (Pl. CCXXXVIII. fig. 25) is now restricted to those species in which the thorax is wider than the head, strongly emarginate before, short, its posterior margin widely truncate, and the lateral edges turned up. The antennæ consist of eleven distinct articulations. In Eurychora,[8] Thunberg, the body is oval, with acute and ciliated edges, the thorax semicircular, and receiving the head in an anterior notch, the abdomen almost heart-shaped, and the antennæ composed of linear articulations, compressed or angular, of which the third is the longest, and the eleventh indistinct.

The following genera of this tribe differ from the preceding in the mentum, of a square form, not being either emarginate or widened at its upper margin. In Tagenia of Lat. (*Akis*, Fab.) the thorax is narrow, and either cylindrical, or in the form of an elongated heart, truncate at both ends. The antennæ are almost perfoliate, with the third articulation scarcely longer than the following ones, and the eleventh or last extremely small, and closely united with the preceding. The head is elongated posteriorly, and borne upon a kind of neck or knob. In Scaurus,[9] Fab. the thorax is at least as broad as the abdomen, almost isometrical. The anterior thighs are strongly inflated, and frequently dentated in the males. The tibiæ are long and narrow. The terminal article of the antennæ is ovoid-conic, and elongated. The species are peculiar to the western countries of the ancient continent, and are confined to its warmer parts. In Scotobius of Germar, the terminal article of the antennæ is scarcely longer than the preceding, and in the form of a reversed top. The thorax is perceptibly broader than long, and much arched in its lateral margins. These insects are peculiar to South America.

Other insects of this tribe, agreeing with those just named in the entireness of the mentum, are remarkable for the lateral dilatations or tooth-like projections of the thorax. The eyes are more projecting than in the others, and the antennæ are pubescent. The elytra are very unequal. Such is the genus Sepidium[10] of Fab. of which the species are found in the southern countries of Europe, and in Africa.

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[1] *Ann. des Sciences Nat.* v. p. 276.

[2] *Ibid.* iii. p. 478.

[3] *Observ. sur les usages des diverses parties du tube intestinal des Insectes. Ann. du Mus.*

[4] From Πιμελης, *fat.*

[5] For the new generic divisions of *Pimelia* of Fabricius, see *Règne Animal*, v. p. 5–7.

[6] From Ζοφωσις, *obscurity.*

[7] From ἄκις, *a javelin.*

[8] From Ευρυχωρος, *wide.*

[9] From Σκαυρος, *having projecting claws.*

[10] From Σηπιδιον, *putridity.*

Coleoptera Hetero-mera.

Among the last to which we shall here allude, is the genus Trachynotus, Lat. (Pl. CCXXXVIII. fig. 26), which differs from the preceding in the joints of the antennæ: these are mostly cylindrical, or in the form of an elongated and reversed cone, the last three or four being alone rounded, and either ovoid, turbinated, or hemispherical. The eyes are almost round or oval, entire, or but slightly emarginate, and elevated. The last article of the antennæ is sensibly longer and thicker than the preceding.

In the genus Moluris, Lat. *Psammodes*, Kirby (Plate CCXXXVIII. fig. 27), the eyes are narrow and elongated, and scarcely elevated. The thorax is convex, nearly orbicular, emarginate in front, truncated posteriorly, and without angular dilatations on the sides. These insects, in common with those immediately preceding, occur at the Cape.

Tribe 2d, Blapsides, Lat.

This tribe receives its name from the genus *Blaps* of Fabricius. The maxillary palpi are terminated by an obviously dilated article, triangular or hatchet-shaped. Among other anatomical observations made by M. Dufour in relation to these insects, he states that they are provided with a double excrementitial secreting apparatus, totally different in structure from that of the pentamerous tribes. It consists of two tolerably large oblong bladders, placed altogether beneath the viscera of digestion and generation, closely approximated to each other, with extremely thin parietes, and surrounded by vascular folds, adherent, more or less pursed or turgid, and of which it is difficult to ascertain the precise point of insertion, from the impossibility of unrolling them. The same may be said of the canals destined to the emission of the secreted fluids. They are concealed by a kind of membranous diaphragm, which is applied, by means of a fleshy pannicle, to the last ventrical segment. The fluid flows out laterally, and not from the extremity of the terminal segment: it is of a brownish colour, extremely acrid and irritating, of a peculiar and penetrating odour, and is capable of being thrown to a distance of six or eight inches.

Those in which the body is generally oblong, with the abdomen laterally embraced by the elytra, and in which these parts are frequently narrowed towards the end, and terminate in a tail-like point, form Latreille's first division. The tarsi are nearly alike in both sexes, and without any remarkable dilatation. In the genus Acanthomera, Lat. (Pl. CCXXXIX. fig. 2), the thorax is almost orbicular, transversal; the abdomen nearly globular; the third article of the antennæ cylindrical, and longer than the ensuing. In Blaps[1] proper (Pl. CCXXXIX. fig. 27) the thorax is almost square, and plane or but slightly convex. The abdomen is oval, transversely truncate at the base, more or less elongated. The elytra, for the most part, are narrowed or prolonged to a point, especially in the males. The third article of the antennæ is cylindrical, and much longer than the ensuing; the last is short and ovoid. As an example of this genus (of which there are three British species), we may name a well-known insect, *B. mortisaga* (ibid.) nearly an inch long, of a somewhat shining black, the ends of the elytra forming an obtuse point. It occurs occasionally in pantries, store-rooms, and other parts of houses, especially such as are dirty or neglected. A species called *Blaps sulcata* is said by Fabricius to be eaten by the Turkish women in Egypt, to make them fat. They cook it with butter. On the same authority, it is asserted to be used as a cure for headach and the sting of the scorpion. In Scotinus of Kirby (Pl. CCXXXIX. fig. 9),[2] the thorax is emarginate and dilated at the anterior corners, and the terminal joints of the antennæ are thickened, the two last being confounded together.

Then follow certain Blapsides with an oval and slightly elongated body, and farther distinguished by a sexual difference in the tarsi, the first or the two anterior pair being most dilated in the males, and their inferior surface usually silky, or furnished with a brush. These insects frequent sandy places. Their two anterior tibiæ are generally wider, dilated triangularly at the extremity, and adapted for digging. Here are placed the genera *Pedinus*, *Blaptinus*, &c. of Latreille, Dejean, and other authors.[3]

Tribe 3d, Tenebrionites, Lat.

These differ from the last in being provided with wings. Their body is usually oval or oblong, depressed or but slightly raised, with the thorax square or trapezoidal, and as wide as the abdomen at its posterior extremity. The palpi are larger at their extremity; the last joint of the maxillary palpi has the form of a reversed triangle, or is hatchet-shaped: the mentum is but slightly widened, and leaves the base of the maxillæ exposed. The genus *Tenebrio*, as originally arranged by Fabricius, together with *Opatrum* and *Orthocerus*, serve in this tribe as the types of as many divisions.

1*st*, Those in which the body is oval, with the thorax nearly trapezoidal, arcuated laterally, or forming a semi-oval truncated anteriorly, wider than the abdomen, at least at its posterior margin, but slightly, if at all, bordered; the maxillary palpi terminated by a securiform joint, or nearly resembling that form; the antennæ insensibly enlarged. Here are placed the genera Crypticus of Lat. and Opatrum, Fabricius.

2*d*, Those in which the body is narrow and elongated, almost of equal breadth posteriorly, or wider, with the thorax nearly square, and at least almost as long as it is broad; the antennæ forming a thickish club, or abruptly dilated at the extremity. Such are, among others, the genera Corticus of Dejean (Pl. CCXXXIX. fig. 13), Orthocerus, Lat. (ibid. fig. 25), and Chiroscelis of Lamarck (ibid. fig. 32).

3*d*, Those of which the body is equally narrow and elongated, with the thorax nearly square, but of which the antennæ are of the ordinary thickness, and not abruptly terminated by a mass or club. In Upis, Lat. (Plate CCXXXIX. fig. 5), the thorax forms a lengthened square; the body is narrow, though not linear; the penultimate joints of the antennæ are lenticular and transversal. In Tenebrio[4] properly so called (ibid. fig. 23), the thorax differs from that of Upis in being broader than long. *T. molitor* (the species figured) is a well-known insect, which appears in the evening in the least frequented parts of houses. It is likewise found in flour-mills, bakehouses, and among old walls. Its larva, commonly called the meal-worm (ibid. fig. 29), is long, cylindrical, of an ochry yellow, scaly in its texture, and smooth. It lives among bran and flour, and forms a favourite and judicious food

[1] From βλαξ, *slow*.

[2] Owing to the accidental omission, by the engraver, of several figures, which were afterwards inserted in the vacant spaces, some of the subjects of Plate CCXXXIX. are by no means in systematic order; but the references in the text will be found correct.

[3] See *Règne Animal*, t. iv. p. 456.

[4] The name refers to the habits of the species, and signifies one that shuns the light.

Coleoptera Heteromera.

for nightingales in the domestic state. It sometimes occurs in the interior of the human body. How it gets there nobody seems to know, but the fact is certain. We have three or four species of the genus in Britain. In a singular genus, named HETEROTARSUS[1] by Latreille (Plate CCXXXIX. fig. 30), the penultimate joint of the tarsi is extremely small, in the form of a little knob, and received into a longitudinal groove of that which precedes it, which is itself more dilated, and almost cordiform (ibid. figs. 34 and 36). The only species with which we are acquainted comes from Senegal. It has all the characters of a Tenebrio, with the exception of its remarkable tarsi. At first sight the two anterior seem to consist but of four joints, and the two others of three. See the figures last referred to.

FAMILY II.—TAXICORNES, Lat.

In this family the small corneous tooth on the inner side of the maxillæ, mentioned in our generalities of the preceding tribes, is wanting. All the species are winged. Their body is generally square, their thorax trapezoidal or semicircular, and either concealing or receiving the head. The antennæ, usually inserted beneath a marginal projection of the sides of the head, are short, more or less perfoliate or granose, and either enlarge insensibly or terminate in a club. The legs are not adapted for running, and all the articles of the tarsi are entire, and terminated by simple hooks; the anterior tibiæ are often broad and triangular. Several males have the head furnished with horns. The greater proportion of these Heteromera occur on tree fungi, or beneath the bark; some live on the ground under stones. M. Dufour has observed an excrementitial secreting apparatus in several genera, and salivary vessels are known to exist in the genus *Diaperis*. The chylific ventricle is beset with little hair-like papillæ.

In some the head is exposed, and never entirely received into a deep anterior notch of the thorax. The latter portion is sometimes trapezoidal or square, sometimes almost cylindrical; its margins, as well as those of the elytra, do not extend perceptibly beyond the body. This division forms

TRIBE 1ST, DIAPERALES, Lat.

In the genus DIAPERIS properly so called[2] (Plate CCXXXIX. fig. 1), the maxillary palpi terminate in an article scarcely thicker than the preceding, and nearly cylindrical; the anterior tibiæ, scarcely, if at all, larger than the following, are narrow, almost linear, and feebly dilated at their extremity. Among the ovoid and convex species, with the central portion of the thorax lobate posteriorly, we may name the insect here figured, *D. boleti*. Its body measures about three or four lines in length; it is of a shining black, with three bands of fulvous yellow, transverse and dentated, upon the elytra. It is a well-known British species, not yet observed in Scotland. In LEIODES of Lat. (*Anisotoma* of Fab.) the body is short and convex, and the antennæ terminate in an oval mass of five joints, of which the second is the least. Mr Stephens enumerates above thirty British species, of which *L. arenaria* was lately discovered near Cramond Bridge, Edinburgh.[3] In this tribe are contained several other genera of minute insects, such as *Tetratoma*, Herbst, *Eledona*, Lat. &c.

TRIBE 2D, COSSYPHENES, Lat.

These are analogous in form to the genus *Peltis* of Fab. and to several Nitidulæ and Cassidæ. They are ovoid or sub-hemispherical, and overlapped in their contour by the dilated sides of the thorax and elytra. The head is in some entirely concealed beneath the thorax,—in others it is received or incased in its anterior emargination. The last joint of the maxillary palpi is larger than the preceding ones, and hatchet-shaped. This tribe corresponds to the unrestricted genus COSSYPHUS of Olivier and Fabricius.

In the genus COSSYPHUS properly so called (Plate CCXXXIX. fig. 3), the thorax is almost semicircular, exhibits no anterior emargination, and entirely covers and conceals the head. The antennæ are short, terminate abruptly in an oval mass of four articles, chiefly transversal: the second of the whole number and the following ones are almost identical. These insects inhabit the East Indies, the south of Europe, and the north of Africa. In HELÆUS of Lat. and Kirby, the head is received into a deep emargination, or median aperture of the thorax, and is exposed at least superiorly. The antennæ terminate gradually in a narrow elongated club. These insects are peculiar to New Holland. Some other species, proper to South America, of which the body is almost hemispherical, very convex, and of a soft or slightly solid consistence, form the genus NILIO of Lat. At first sight they remind one of Coccinellæ, and of various species of Erotyli.

FAMILY III.—STENELYTRA,[4] Lat.

This family of heteromerous Coleoptera differs from the preceding one chiefly in the antennæ, which are neither granose nor perfoliated. In the greater number the extremity is not thickened. The body is generally oblong, arcuated above, and the legs elongated, as in many other insects. The males, except in their antennæ and general dimensions, resemble the females. Our present species generally are of much more active habits than those we have just left. Many conceal themselves beneath the bark of trees, while most of the others are met with on flowers and foliage. Linnæus referred most of them to his genus *Tenebrio*, and distributed the remainder among the incongruous groups of *Necydalis, Chrysomela, Cerambyx*, and *Cantharis*. In the first edition of the *Règne Animal*, Latreille combined them under a single genus, that of *Helops*; but a more intimate knowledge of their structure, interior as well as exterior, has since induced him to partition them into five tribes, referable to a corresponding number of the older genera, viz. *Helops, Cistela, Dircæa*, of Fab. and *Œdemera* and *Mycterus* of Olivier. In *Œdemera* the head is more or less narrowed, and prolonged anteriorly in the form of a muzzle, and the penultimate article of the tarsi is always bilobed,—a character which seems to connect these insects with the weevils, or rhyncophorous Coleoptera. In respect to the digestive canal, and some other considerations, *Helops* and *Cistela* approach the Tenebriones; but in Cistela the chylific ventricle is smooth, and the mandibles entire, and the species affect flowers and leaves, a habit by which they are distinguished from Helops. Most of the Dirceæ possess the faculty of leaping, and the penultimate article of the tarsi, or at least of some of them, is bifid. Some live in mushrooms, others in old wood. They connect on one side with He-

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[1] From ἕτερος, *different*, and ταρσος, *a part of the foot or hand.*

[2] From διαπειρω, *to pierce through.*

[3] *Entomologia Edinensis*, p. 145. We also possess an undescribed species, from the same locality, named in our cabinet *L. fuscicollis.*

[4] From στενος, *narrow*, and ελυτρον, *sheath*, in reference to the form of the elytra.

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lops, and on the other with Œdemera, and still more with that sub-genus of the same tribe named *Nothus* by Ziegler. These are the principles by which Latreille has been recently directed in his arrangement of the present family.

A certain number (including the first four tribes) have the antennæ approximate to the eyes, and the head not prolonged into a trunk, but terminated at most by a short muzzle.

Tribe 1st, Helopii.

Antennæ covered at their insertion by the margins of the head, almost filiform, or a little larger towards the extremity, generally composed of nearly cylindrical articles attenuated towards the base, and of which the penultimate are frequently a little shorter, in the form of a reversed cone,—the terminal being for the most part nearly ovoid, and the third always lengthened. The extremity of the mandibles is bifid; the last joint of the maxillary palpi is of larger size, and hatchet-shaped, or in the form of a reversed triangle. The eyes are oblong, reniform, or emarginate. None of the legs are adapted for leaping; the penultimate joint of the tarsi, or at least of the hindmost ones, is almost always entire, or not deeply bilobed; the terminal hooks are simple, or without fissure or dentation. The body is for the most part arcuated above, and always of a firm and solid consistence. Such of the larvæ as are known are filiform, smooth, shining, with very short feet, like those of the Tenebriones. They occur in old wood. It is also beneath the bark of ancient trees that we find the perfect insects. The tribe corresponds in great part to the genus *Helops* of Fabricius.

Some have the body almost elliptical, strongly arcuated above, or very convex, with the antennæ at the utmost as long as the thorax, compressed and dilated towards their extremity, like the teeth of a saw; the thorax transversal, plane above, either trapezoidal and widening posteriorly, or almost square; the elytra frequently terminated by a point or tooth. The posterior extremity of the præsternum forms a little salient point, which is received by a forked notch of the mesosternum. Here are placed the genera Epitragus and Cnodalon of Lat. and Campsia of Lepelletier and Serville.

In all the other Helopii, the mesosternum exhibits no marked emargination, and the posterior extremity of the præsternum is not prolonged to a point. Here are placed the genera Spheniscus of Kirby, Acanthopus of Megerle and Dejean, Amarygmus of Dalman, Sphærotus and Adelium of Kirby, and Helops properly so called. In the last named, most of the joints of the antennæ are nearly in the form of a reversed cone, or cylindrical and attenuated at the base. The thorax is transverse, or scarcely as long as broad, either square, or trapezoidal, or heart-shaped, abruptly narrowed posteriorly, terminated by pointed angles, and always applied exactly to the base of the elytra. Here also are placed the genera Læna of Megerle, Stenotrachelus, Strongylium of Kirby, and Pytho of Latreille.[1]

Tribe 2d, Cistelides.

This is very closely allied to the preceding, but the insertion of the antennæ is not covered. The mandibles terminate in an entire point, or are unemarginate. The hooks of the tarsi are dentated beneath like the teeth of a comb. Several of these insects live on flowers. Their digestive canal is shorter than that of the Helopii, and the chylific ventricle exhibits no papillæ. They correspond to the genus *Cistela* of Fabricius.

In some all the articles of the tarsi are entire. The last joint of the maxillary palpi is simply a little larger, obconical or triangular. In Lystronichus, Lat., the thorax is thick, narrower than the abdomen, almost orbicular or heart-shaped. The antennæ are thickened towards the extremity. The thighs are clubbed. In Cistela properly so called, the thorax is depressed, trapezoidal, of the breadth of the abdomen at its posterior margin, or scarcely narrower. The antennæ are filiform, or slightly enlarged at the extremity, and the head is advanced in the manner of a muzzle. In others, such as the genus *Allecula*, Fab., the penultimate article of the tarsi is bilobed, and the last joint of the maxillary palpi much dilated, in the form of a hatchet. The body is generally more oblong.

Tribe 3d, Serropalpides.

The most remarkable distinction of this tribe, and that from which it derives its name, is the frequent serration of the maxillary palpi, which are likewise large and inclined. The antennæ are inserted in an emargination of the eyes, exposed as in the preceding tribe, and often short and filiform. The mandibles are emarginate or bifid at the extremity, and the hooks of the tarsi are simple. The body is almost cylindrical in some, oval in others, with the head inclined and the thorax trapezoidal. The anterior extremity of the head is not advanced, and the posterior thighs are not inflated. The penultimate article of the tarsi, or at least of the four anterior, is frequently bilobed; and in those in which it is entire the posterior legs at least are adapted for leaping; they are thin, long, compressed, the tarsi small, almost setaceous, with the first article elongated. The anterior are always short and dilated. The genus *Dircæa* of Fabricius forms the type of the tribe. It contains the genera Orchesia, Lat., Eustrophus, Illiger, Hallomenus, Paykul, Dircæa (proper), Fab., Melandrya, Fab., Hypulus, Paykul, Serropalpus, Hellw., and Conopalpus, Gyll.

Tribe 4th, Œdemerites.[2]

This tribe is allied to the preceding by several characters, such as the exposed insertion of the antennæ near the eyes, the bifid extremity of the mandibles, the bilobation of the penultimate article of the tarsi, and the hatchet shape of the terminal joint of the maxillary palpi; but they exhibit other characters, which authorize their separation. The body is elongated, narrow, almost linear, with the head and thorax scarcely so broad as the abdomen; the antennæ are longer than those parts, serrated in some (such as *Calopus*), filiform or setaceous, and composed of long and nearly cylindrical articles, in others. The anterior extremity of the head is more or less prolonged in the form of a small muzzle, and rather restricted behind, with the eyes proportionally more elevated than among the preceding tribes. The thorax is at least as long as wide, and a little narrowed behind. The elytra are linear, or narrowed posteriorly, and are frequently flexible. Latreille regards the species as allied to *Telephorus* and *Zonitis*. M. Dufour has recognised in the Œdemerites the existence of salivary vessels, of a simple nature, flexuous and floating, as well as of a paunch formed by a lateral crop, furnished with a neck or pedicle.

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[1] For the details of these and other genera of the tribe which we have been unable to do more than name, we must refer the reader to Latreille's *Genera Crustac. et Insect.*; the *Encyclop. Méthod.*; *Linn. Trans.* vol. xii.; Dalman's *Analecta Entomol.*; Dejean's *Catalogue*, and Fischer's *Entomog. de la Russie.*

[2] From οἰδέω, *I swell*, and μηρος, *thigh.*

Coleoptera Heteromera.

They are the only Coleoptera in which that character has been observed. These insects, of which the transformations are unknown, are found on flowers and trees. They are all comprised in the old genus *Œdemera* of Olivier.

In some the antennæ are always short, inserted in a notch of the eyes, and simple; the posterior thighs are inflated, at least in one of the sexes; the thorax as broad as the base of the abdomen; and the hooks of the tarsi bifid. Such is the genus Nothus of Ziegler, in which the maxillary palpi are terminated by a large elongated hatchet-shaped article. The posterior legs in one of the sexes are very large, and furnished beneath with a strong tooth and two little spurs, near the lower extremity of the tibiæ. The head is not prolonged anteriorly.

In others the antennæ are always longer than the head and thorax, the legs usually of nearly equal size, the thorax narrower than the base of the abdomen, slightly narrowed posteriorly, and the hooks of the tarsi entire. Such are Calopus, Fab. Sparedrus, Megerle, Dytilus, Fisch. and Œdemera properly so called (Pl. CCXXXIX. fig. 4).

Tribe 5th, Rhynchostoma.[1]

In this, which forms the concluding tribe of the Stenelytra, are grouped certain insects, some of which are evidently allied to the preceding, while others in a natural system might be regarded as belonging to the *Rhyncophori.* The head is obviously prolonged anteriorly in the form of an elongated muzzle, or of a flattened trunk, bearing the antennæ at its base, and in advance of the eyes, which are always entire or without emargination.

Sometimes the antennæ are filiform, and the muzzle not enlarged at the base; the thorax is narrowed in front in form of a truncated cone or of a trapezium; the ligula is emarginate, and the terminal joint of the tarsi bilobed. These insects occur on flowers, a habitat indicated by the silky prolongation of the terminal lobe of the maxillæ. Such are the genera Stenostoma, Fab. and Mycterus, Clairville.

Sometimes the antennæ are terminated by an elongated mass, formed by from three to five terminal joints; the muzzle is very flat, with a projecting angle on each side, anterior to the extremity; the thorax is in the form of a truncated heart, narrowed posteriorly; the ligula and all the joints of the tarsi are entire. These insects dwell beneath the bark of trees, and seem allied to the *Anthribi* of Fabricius. They form the genus Rhinosimus of Lat. and Oliv. Those of which the club of the antennæ consists of only three articles, fall under the genus Salpingus of Illiger. We have several British species.

The second general division of heteromerous Coleoptera forms

FAMILY IV.—TRACHELIDES.

The head is triangular or heart-shaped, borne upon a kind of neck or abrupt pedicle; the body is usually soft; the elytra flexible, without striæ, sometimes very short, in others slightly inclined. The maxillæ are not unguiculated. The joints of the tarsi are often entire, and the hooks of the posterior ones bifid. The majority of these insects live in the perfect state on various plants, of which they devour the foliage, or suck the nectarous juices. Many, when seized, bend their heads, contract their limbs, and simulate death. Others are extremely active. Latreille divides them into six tribes.

Tribe 1st, Lagriariæ.

These have the body elongated, and narrower in front; the thorax either almost cylindrical or square, or ovoid and truncated. The antennæ, inserted near a notch on the eyes, are simple, filiform, or insensibly increasing towards the extremity, generally and at least partially granose, with the terminal article longer than the preceding in the males. The palpi are thickened at their extremity, and the terminal joint of the maxillary is larger, and in the form of a reversed triangle. The thighs are oval and clubbed; the tibiæ elongated, narrow, with at least the two anterior arched. The penultimate article of the tarsi is bilobed, and the hooks of the last are neither incised nor dentated. The tribe is formed of the genus Lagria of Fabricius, subdivided in accordance with certain characters detailed in the *Règne Animal,* t. v. p. 52.

Tribe 2d, Pyrochroides,

Approach the preceding in regard to the tarsi and the elongation and restriction of the anterior part of the body,—but the latter is flattened, with the thorax almost orbicular or trapezoidal. The antennæ, at least in the males, are pectinated or plumose—*en panache;* the maxillary palpi are somewhat toothed or serrated, and terminate in an elongated and almost hatchet-shaped article; the labial palpi are filiform. The abdomen is elongated, entirely covered by the elytra, and rounded at the end. These insects are found in woods in spring. The larvæ dwell beneath the bark of trees.

In the genus Dendroides, Lat. the antennæ of the males are almost as long as the body, and give off long bearded filaments; in the same sex the eyes are large, and approximated behind. The thorax is trapezoidal, or in the form of a truncated cone; and the body, as well as the legs, is proportionally more elongated. In the genus Pyrochroa properly so called[2] (Pl. CCXXXIX. fig. 6) the antennæ are shorter and simply pectinated, the eyes distant, and the thorax almost orbicular and transversal.

Tribe 3d, Mordellonæ.

These do not present, either in relation to the form of the tarsi and their hooks, or to that of the antennæ, any constant character in common, but they are easily distinguished from the other Heteromera of the same family by the general conformation of their body. It is elevated, and arcuated; the head is low, the thorax trapezoidal or semicircular, and the elytra either very short, or narrowed, and terminated by a point, as well as the abdomen. Several of these insects approach the Pyrochroides in respect to their antennæ;—others in their maxillæ, the hooks of the tarsi, and their parasitical habits, resemble *Nemognathus* and *Sitaris,* two genera of an ensuing tribe; —but they differ from all of these in their extreme agility, and the firm and solid consistence of their teguments. They formed the old genus *Mordella* of Linn.

Some have the palpi almost of the same thickness throughout. The antennæ of the males are strongly pectinated or fan-like. The extremity of the mandibles offers no emargination. The articles of the tarsi are always entire, and the hooks of the hindmost are dentated or bifid. The middle of the posterior margin of the thorax is always much prolonged backwards, like a scutellum. The eyes are unemarginate. The larvæ of certain species (*Ripiphori*) live in the nests of wasps.

The genus Ripiphorus of Bosc (Pl. CCXXXIX. fig. 7)

[1] From ρυγχος, *beak,* and στόμα, *mouth.*

[2] From πυρ, *fire,* and ωχρος, *yellow.*

has the wings extended, and reaching beyond the elytra, which equal the length of the abdomen. The hooks of the tarsi are bifid. The antennæ, inserted near the inner edge of the eyes, are pectinated on both sides in the males,—serrated, or with only a single range of short teeth, in the females. The terminal lobe of the maxillæ is very long, linear, and projecting; and the ligula is also elongated, and deeply bifid. Some naturalists having found in the nest of the common wasp several living specimens of *R. paradoxus*, it has been inferred that they live there in the larva state. M. Farines, however, has observed that the larva of *R. bimaculatus* lives and undergoes its transformations in the roots of *Eryngium campestre*.[1] Here are placed the genera Pelocotoma of Fischer, and Myodites of Lat.

Others have the wings always covered by the elytra, which are prolonged nearly to the extremity of the abdomen, and terminate in a point. The posterior margin of the thorax is slightly if at all lobed. The abdomen of the females is terminated by a pointed tail. The eyes are sometimes emarginate. The maxillary palpi are terminated by a large article, in the form of a hatchet or reversed triangle. The extremity of the mandibles is notched or bifid. The antennæ, even in the males, are merely serrated. In Mordella properly so called (Pl. CCXXXIX. fig. 8), the antennæ, of equal size throughout, are slightly serrated in the males. All the articles of the tarsi are entire, and the hooks of the last present beneath one or two small indentations. M. Dufour has observed in a species of this genus two floating salivary vessels, longer than the body. The hepatic vessels have no cæcal insertion,—an exceptive character in the present section. The genus Anaspis,[2] Geoff. is distinguished from the preceding by the antennæ, which are simple, and gradually enlarged, by the emargination of the eyes, and by the four anterior tarsi, of which the penultimate article is bilobed. The hooks of the last are entire and without sensible dentations.

Tribe 4th, Anthicides.

Here the antennæ are simple, or slightly serrate, filiform, or a little thicker towards the end, and most of the articles are in the form of a reversed cone, and nearly alike, except the last (and sometimes also the two preceding), which is larger and oval. The maxillary palpi are terminated by a securiform club. The penultimate joint of the tarsi is bilobed. The body is narrow anteriorly, with the eyes entire or slightly emarginate. The thorax is sometimes in the form of a reversed oval, narrowed and truncated posteriorly, sometimes divided into two knots, in others semicircular. Certain species are found on plants of different kinds, but the majority occur upon the ground. They run with great swiftness, and their larvæ have been supposed to be parasitical. They compose the genus Notoxus[3] of Geoffroy, which Latreille divides into Seraptia, Steropis, and Notoxus properly so called.[4]

The two concluding tribes of this family, and of the heteromerous section, exhibit certain characters in common, such as the termination of the mandibles in a simple point, the palpi filiform or simply a little longer at their extremity, but never either clubbed or securiform, the abdomen soft, the elytra flexible, and in most instances blistering or vesicatorial, and, with few exceptions, the articles of the tarsi entire, and the hooks of these parts generally bifid. They are all herbivorous in the perfect state, but many are parasitical, while larvæ, in the dwellings of other tribes.

Tribe 5th, Horiales.

These differ from the ensuing, or Cantharidiæ, in their hooks, which are dentated, and each accompanied by a serrated appendage. The antennæ are filiform, not longer than the thorax; the labrum is small, the mandibles strong and projecting, the palpi filiform, the thorax square, and the two posterior legs very robust, at least in one of the sexes. The tribe is composed of the genus Horia of Fabricius (Pl. CCXXXIX. fig. 10). These insects inhabit the intratropical regions of India and America. The lamented Lansdown Guilding has published figures and a short history of *H. maculata*.[5] It deposits its eggs in the nest of a wood-gnawing bee (*Xylocopa teredo*), and the larvæ, when hatched, are supposed to devour the food deposited in the ligneous chambers for a very different purpose by the parent bee. "Forsan," says Mr Guilding, "dum larva cibum apibus præparatum avide consumit, hospes fame perit." It is often so.

Tribe 6th, Cantharidiæ.

This tribe is distinguished from the preceding by the hooks of the tarsi, which are deeply divided, and appear as if double. The head is generally large, broader, and rounded posteriorly. The thorax is usually narrowed behind, and approaches the form of a truncated heart; in some it is almost orbicular. The elytra are often somewhat inclined laterally, or tectiform, and rounded. These insects counterfeit death when seized, and several of them exude a yellow caustic liquor, of a penetrating odour, from the joints of their antennæ; but no peculiar apparatus for the production of that secretion has yet been ascertained. Many kinds are highly serviceable in the formation of blistering applications. They were all included originally in the old genus Meloe of Linnæus, now greatly subdivided. The anatomical observations of M. Dufour, and the extremely interesting researches of M. Bretonneau of Tours, on the vesicatorial properties of this tribe of insects, have enabled Latreille to arrange them in what he regards as a natural order,—not greatly differing, however, from that which he had previously adopted. M. Bretonneau has ascertained that the genus *Sitaris* is not vesicatorial,—and M. Dufour has found that these same Heteromera possess only four biliary vessels instead of six, the amount by which other insects of the tribe are characterized. That genus also resembles *Zonitis* in its general organization, while the latter is itself closely allied to *Cantharis*. The series of groups adopted by Latreille is also in harmony with the progressive changes in the form of the antennæ.

In some these organs are composed in both sexes of only nine articulations, of which the last is large, and in the form of an ovoid head; those of the males, as well as their maxillary palpi, being very irregular. The body is depressed. Such is the genus Cerocoma of Geoff. The species make their appearance during the summer solstice, and frequently in great numbers on the same spot. They frequent the flowers of the wild chamomile, milfoil, &c. *Meloe Schæfferi* of Linn. of a bluish green, with the antennæ and legs wax yellow, may be mentioned as an example.

In all the others the palpi are identical and regular in

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[1] *Annales des Sciences Nat.* viii. 224; and *Nouv. Dict. d'Hist. Nat.* second edition, art. *Ripiphore.*

[2] From α priv. and ασπις, *scutellum.*

[3] From νωτος, *back*, and οξυς, *pointed.*

[4] See *Règne Animal*, t. v. p. 58; and *Mém. des Nat. de Moscou*, i. 166.

[5] *Linn. Trans.* vol. xiv. part ii. p. 315.

Coleoptera Heteromera.

both sexes. The antennæ have generally eleven articulations, and when they offer one or two less they terminate regularly in a club. The body is thickish, and the elytra somewhat inclined.

In some the antennæ, always regular and granose in both sexes, sometimes appear to be composed of only from nine to ten joints, and are not longer than half the body; they occasionally terminate in an arcuated club, or are obviously enlarged at the extremity; while in others they form from the second joint a short cylindrical or almost fusiform stem. They constitute the genus *Mylabris* of Fabricius. Such of them as have the two or three last joints of the antennæ united, at least in the females, and forming an abrupt, thick, ovoid, or button-shaped club, the extremity of which does not extend beyond the thorax, and in which the total joints are only from nine to ten, form the genus Hycleus of Lat. Such, again, as have the antennæ proportionally longer, and offering in both sexes eleven distinct and well-divided articulations, gradually enlarging, or terminating by degrees in an elongated club, of which the terminal joint, very distinguishable from the preceding, is large and ovoid, belong to the genus Mylabris properly so called (Pl. CCXXXIX. fig. 11). The species we have here represented is the *M. chicorii.* It is more than half an inch long, black, pilose, with an almost round yellowish spot on the base of each elytron, and two transverse and indented bands of the same colour, one near the centre, and the other nearer the extremity. The antennæ are black. This insect, unknown in Britain, is occasionally found as far north as the vicinity of Paris, but it is much more common in the south of France, and other meridional parts of Europe. Its blistering qualities are quite as active and efficient as those of the true *Cantharis* or Spanish fly; and in Italy it is employed for the same purposes, mixed up with the latter, or even used alone. *M. pustulatus* is used by the Chinese.

In the other Heteromera of this tribe the antennæ, always composed of eleven very distinct joints, are almost of equal thickness throughout, or rather more slender towards the extremity, and frequently much longer than the head and thorax. They are irregular in several males. In Meloe properly so called (Pl. CCXXXIX. fig. 12), the antennæ are composed of short and rounded joints, the intermediate of which are the largest, and sometimes so disposed that these parts in the males exhibit an emargination or crescent-like form. The wings are wanting, and the elytra, oval or triangular, with a portion of the inner margins crossing each other, only partially cover the abdomen, especially that of the females, which, as often happens, is extremely voluminous. According to Dufour, the crop of these insects may be considered as a true gizzard, being furnished internally with callous and anastomosing plicæ, and separated from the stomach or chylific ventricle by a valve formed of four principal pieces, each of which results from two hollow cylinders placed back to back, and tridentated posteriorly.

All the species of the genus Meloe are awkward and mis-shapen, and of sluggish movements. They are found either crawling slowly and heavily along the surface of the earth, or on plants of humble growth. They feed on leaves, and when handled, an oily fluid of a yellow or reddish colour flows from the joints of their legs. Latreille suspects that these insects are the *Buprestides* of the ancients, to which were attributed such destructive effects on cattle, when inadvertently swallowed by the latter. The genus seems characteristic of the European continent and islands. Eight or nine species occur in Britain; and of the twenty-one species enumerated by Dejean, the whole are European. Mr Kirby however possesses a specimen taken in North America by Professor Peck. They are all characterized by dark or sombre colours. They are most frequent in spring and autumn, and occur in fields and pathways, preferring, it is said, a sunny situation and a sandy soil. In some districts of Spain they are employed along with Cantharides, or in their room. They are also used by farriers.[1] The females, when filled with eggs, become greatly dilated, and in that condition much exceed the males in size. An individual of the former sex observed by Goëdart, and fed by him with the leaves of anemone and ranunculus, laid 2212 eggs between the 12th of May and the 12th of June, besides about as many more which were thrown aside uncounted. It effected this laying at two separate periods, placing the extremity of its abdomen in a hole which it had formed in the earth, and depositing the eggs in packets. These are of a yellowish colour, and resemble grains of sand pressed together. The larvæ are long, cylindrical, garnished with scattered hairs, composed of eleven nearly equal segments, besides the head, which is oval, and provided with two eyes, and a pair of longish antennæ. They have six legs, of rather large size compared with the length of the body, which is terminated by two long bristle-like appendices. Their larvæ are supposed by some ingenious observers to be parasitical on the bodies of winged insects. Degeer having remarked that a strong resemblance existed between the larvæ of Meloe, and a small insect which he found adhering to *Eristalis intricarius,* he placed two domestic flies among the former, and found that they were speedily adhered to by the larvæ, which stuck to them pertinaceously, and caused their death in two or three days. Bees are also subject to their attacks; and MM. Lepelletier and Serville are said to have recently confirmed the observations of Degeer, by breeding these parasites from the eggs of Meloe. " On the other hand," says Mr Curtis, " Mr Kirby is disposed to think that his *Pediculus Melittæ* (P. Apis, Linn.?) is not the larva of Meloe; and M. Leon Dufour has even formed them into a *genus* under the name of *Triungularis andrenetarum;* and a figure of one is given in the thirteenth volume of the *Annales des Sciences Naturelles.*"[2] M. Latreille seems to adopt the opinion of their parasitical nature; and the facts, so far as known, are well stated by M. Walkenaer, in his *Memoires pour servir à l'Histoire Naturelle des Halictes.*[3] The digestive system of the genus Meloe, with other anatomical details, has been illustrated by M. Dufour;[4] and we are indebted for a monograph of the British species to Dr Leach.[5]

All the ensuing genera of the tribe are provided with

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[1] In regard to these insects we may further observe, that Dr Leach was informed by Mr Hunneman that the species called *M. variegatus* is highly prized in Germany as a medicine, being considered as a specific in hydrophobia. For this purpose it is taken by slipping a hair round its neck, and suspending it till dry; the oily secretion first thrown out being preserved, as in that the chief virtue is supposed to exist. Mr Hunneman adds more particularly, that the late king of Prussia, Frederick the Great, purchased the nostrum from the discoverer for a valuable consideration, as a specific against the bite of a mad dog. According to the recipe, twenty-five of these insects that have been preserved in honey, are, with two drachms of powdered black ebony, one drachm of Virginia snake-root, one ditto of lead filings, and twenty grains of fungus sorbi, to be reduced to a very fine substance; the whole, with two ounces of theriaca of Venice (and, *if necessary,* a little elder root), to be formed into an electuary! (See *Linn. Trans.* xi. p. 245.

[2] *Brit. Ent.* vol. vi. fol. 279.

[3] See also *Introduction to Entomology,* vol. iv. p. 225.

[4] *Ann. des Sciences Nat.* t. iii. p. 486.

[5] *Linn. Trans.* xi. p. 35 and 242.

Coleoptera Heteromera.

wings, and elytra, of the ordinary structure, covering longitudinally the back of the abdomen. In the genus CANTHARIS, Geoff. (Pl. CCXXXIX. fig. 14), all the joints of the tarsi are entire, the thorax almost ovoid, a little elongated, and restricted anteriorly, truncated posteriorly. The second joint of the antennæ is much shorter than the following, and the last of the maxillary palpi is sensibly larger than the preceding. The head is a little broader than the thorax. The antennæ of the males are sometimes irregular, and even semi-pectinated. The name of Cantharis is extremely ancient, and has been received in a variety of acceptations. Aristotle did not apply it to any particular insect, but to various Coleoptera.[1] Linnæus made use of the term to designate a great genus of the same order, which, however, did not include the true Cantharis, which he placed in *Meloe*. Geoffroy substituted the name *Cicindela*, already otherwise employed, for that of Cantharis, and placed in the latter the genuine Spanish fly. Fabricius placed it in his genus *Lytta*, which corresponds to Cantharis of Geoffroy. The latter, however, amidst all these revolutions of names, appears to have maintained its ground, and to have been the most generally adopted.

The Cantharides properly so called have an elongated and almost cylindrical form. The history of the most noted species, *C. vesicatoria*, commonly called the Spanish fly (fig. 14), is still somewhat doubtful, so far as concerns our knowledge of its transformations. Neither Degeer nor Geoffroy ever saw the larva. Those who suppose themselves to have seen it say that it feeds on various roots, and is metamorphosed in the earth,—an observation which accords with the usually sudden appearance of the perfect insect, the unexpected apparition of which has sometimes given rise to the belief that they migrated from more southern regions. It is described by Olivier as consisting, in its early state, of thirteen segments, soft, of a yellowish-white, with six short scaly feet,—the head rounded and flattish, and furnished with two short filiform antennæ. The mouth consists of a pair of tolerably solid maxillæ and four palpi. The medicinal uses of this now celebrated beetle are universally known, but its connection with the sanitory art is not traceable to a remote antiquity; for the Cantharis of the ancients was certainly not the same as the Spanish fly, and is even supposed to have belonged to a different genus. According to the testimony of Pliny and Dioscorides, who affirm that the best Cantharides are such as are marked with transverse yellow bands, it becomes evident that their species was the *Mylabris chicorii* already mentioned, which in China is used for epispastic preparations down to the present day. The insect of the European laboratories, *C. vesicatoria*, is of a beautiful golden green, with black antennæ. The males are less than the females, and there exists in general a great variety of size among different individuals. These insects are very common in France,[2] Italy, and Spain. The greater proportion employed in commerce come from the last-named country, and hence their common name. Their collection requires precaution on the part of those who are employed in that office, both with a view to guard against injurious accidents, and for the proper preservation of the objects themselves. They are killed by means of vapour of vinegar, and completely dried after they are dead. The following is the plan of procedure: In the course of the month of June the natives place extended cloths or sheets beneath the trees on which the Cantharides occur, and make them tumble down by beating all the branches. When they have obtained a considerable quantity, they either put them into a hair sieve, which they place over the vapour of vinegar, or into a fine cloth, which they dip repeatedly in a vessel containing diluted vinegar. They are then allowed to dry under the shade of some loft or granary, being placed on hurdles covered with cloth or paper, and stirred occasionally with a stick, or with the hand protected by a stout glove. When thoroughly dry they are packed into vessels of wood or glass, which are afterwards carefully and tightly closed. These little processes being properly attended to, the insects retain their blistering qualities for a length of time.

Coleoptera Tetramera.

The chemical analysis of Cantharides has been made by numerous experimentalists, who appear, however, to have confined their researches rather too exclusively to the Spanish fly. Had they studied with equal assiduity the genera *Meloe* and *Mylabris*, and even *Carabus*, *Coccinella*, and several *Tenebriones*, they would have discovered in these also an analogous or identical principle, less active perhaps in its nature, but for that very reason susceptible of being employed with greater advantage in special cases. Thouvenet, Fourcroy, Beaupoil, Orfila, and especially Robiquet, have arrived at some remarkable results. The latter has demonstrated the existence of a particular substance, on which he has bestowed the name of *Cantharadine*, and which may be characterized as white, crystalline, insoluble in water, soluble in boiling alcohol, in ether, and in oils. It is the seat of the vesicatorial or blistering property, which does not therefore reside in the green oil, nor in the black insoluble matter, nor in the yellow matter soluble in alcohol and in water,—the other ingredients of which analysis has demonstrated the presence. This discovery, though important in a scientific point of view, has produced no alteration in the practice, which proceeds effectually enough upon the old experience, that when the substance of the insect is reduced to powder, mixed up with some fatty matter, and applied to the surface of the body, it immediately proceeds to action, and detaches the outer skin from the dermis with great rapidity. It is also used for several other purposes.[3] Naturalists are acquainted with many other species of Cantharis besides the Spanish fly. Of these we may mention *C. Syriaca* of Olivier, which occurs in Syria and the south of Europe, and the *C. dubia* of the same author, found in the southern provinces of France, Italy, the Levant, and Siberia. In the United States a species, described by Fabricius under the name of *vittata*, is employed for medicinal purposes. It is found in great abundance among potatoes.

The remaining genera of the tribe are ZONITIS, Fab. NEMOGNATHUS, Lat. GNATHIUM, Kirby, and SITARIS, Lat.

TETRAMERA.

Four Articulations to all the Tarsi.

The numerous and important groups which constitute this, the third primary section of the coleopterous order, are all vegetable feeders. The larvæ have very short

[1] *Hist. Animal*, lib. iv. cap. 7.

[2] Latreille observes that they appear in France about the period of the summer solstice, and that they occur more particularly on the ash and lilac, on the leaves of which they feed. They diffuse around them a peculiar and highly penetrating odour.

[3] See *Annales des Sciences Nat.* ix. p. 31; and *Diction. Class. d'Hist. Nat.* iii. p. 156.

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feet, and in many even these seem wanting, or are replaced by mammillæ. The perfect insects occur among flowers and plants. Latreille divides them into seven families. The larvæ of the first four or five most commonly live concealed in the interior of plants, and are generally destitute of feet, or have these organs extremely small; many attack the hard or ligneous portion of their dwelling. These Coleoptera are the largest of their section.

FAMILY I.—RHYNCHOPHORA.[1]

This numerous and widely extended family, so remarkable for the beauty of its South American species, is easily recognised by its more or less extended muzzle, terminated by a mouth, of which the parts, from their peculiar structure and position, are not easily determined without the aid of microscopical examination and dissection. The abdomen is generally of a bulky form, the antennæ geniculate and clavate, and the penultimate joint of the tarsi almost always bilobate. In many tribes the posterior thighs are dentated. The body of the larvæ is oblong, and resembles a small white worm, exceedingly soft. The head is squamous or scaly, and the feet are either wanting or mammillæform. They live by gnawing the various parts of plants. Many dwell exclusively in the interior of fruits and seeds, and do great damage to the farmer, grain-dealer, and horticulturist. Some, such as the Brachyceri, are supposed to live beneath the ground, and to feed on roots.

The muzzle in this richly adorned family differs essentially from the *rostrum* of the hemipterous species. It is in fact merely a prolongation of the head, and not composed of the parts of the mouth, as in the last-named order. This prolongation, however, exerts an influence over the alimentary tube, the œsophagus being thereby somewhat prolonged, and—as we find to be the case in the truly suctorial tribes—there is also a provision of salivary glands.

We have little detailed information regarding the internal structure of the Curculionidæ. Two species (*Attelabus betuleti* and *Cryptorhynchus lapathi*) have been examined and described by Ramdhor.[2] In both of these the alimentary canal was moderately long, the stomach partially shaggy, and the small intestine inversely claviform. In other respects, however, they differed materially. There was no crop or gizzard in the former, the stomach was fringed on each side, except at its upper extremity, with a series of small cæca or shags, and there were three pair of bile-vessels; in the latter the gullet was dilated into a crop, which included a gizzard of singular and exquisite construction; for, though so minute as scarcely to exceed a large pin's head in size, it was found to be provided internally with more than four hundred pairs of teeth, moved by an infinitely greater number of muscles. A transverse section of this gizzard represented two concentric stars, with nine rays each, the object of this structure being the comminution of the timber which the insect has to perforate, and probably devour. The stomach was very slender, but dilated in the middle into a spherical vesicle; and only two pairs of bile vessels were observable.[3]

It may well be supposed, that in a family consisting of not much less than three thousand ascertained species, many diversities occur both in habit and external structure. The antennæ are sometimes straight, but more frequently have an angular bend. They are inserted either towards the extremity of the muzzle when that organ is short, or nearer the centre, or even towards the base in the long snouted species. The number of the articulations of the antennæ varies in certain genera from six to ten; but eleven is the more usual number, or even twelve, if we count the false or terminal article. The body is generally narrowest in front, with a large abdomen covered by very hard elytra. The tarsi are very frequently garnished beneath with short hairs. None of the species are carnivorous in any degree; but even in the perfect state they are sometimes extremely noxious, when they happen, as they sometimes do, to occur in great abundance. They tap the buds and leaves of trees, and of several cultivated vegetables, and feed upon their juices.

TRIBE 1ST, BRUCHELÆ, Lat.

Labrum apparent, anterior elongation of the head short, broad, depressed, and in the form of a snout. Palpi very

[1] Since the publication of the first edition of the *Règne Animal*, considerable attention has been bestowed on this difficult family. Messrs Germar and Schœnherr, more particularly, have devoted their time to its elucidation; and the latter author (in his *Curculionidum Dispositio Methodica*, Leipsic, 1826) gives a hundred and ninety-four genera, exclusive of sub-genera. He divides the Curculionidæ, in accordance with the straightness or geniculation of their antennæ, into two great sections, the *Recticornes* or *Orthocera*, and *Fracticornes* or *Gonatocera*. The recent observations of M. Leon Dufour on the internal structure of these insects seem to strengthen the propriety of that classification. The species of the latter section are furnished with salivary vessels, which are wanting in those of the former. In Latreille's recent reconstruction of Schœnherr's arrangement, the Recticornes compose four tribes—the *Brucheles*, the *Anthribides*, the *Attelabides*, and the *Brentides*. In the first two the labrum and palpi are very visible; these palpi are filiform or larger at the extremity; they are small and conical in the two other tribes, as in all the following Rhynchophora. The Fracticornes form a fifth tribe, viz. the *Curculionites*. These are divided into the *Brevirostres* and the *Longirostres* terms which bear relation to the place of insertion of the antennæ. In the former these organs are attached to the extremity of the muzzle, or on a line with the base of the mandibles,—while they are placed further back, or nearer the head, in the latter. The genera of the *Brevirostres* are arranged in three subtribes, viz. *Pachyrhyncides*, *Brachycerides*, and *Liparides*,—corresponding to the genera Curculio, Brachycerus, and Liparus of Olivier; the last sub-tribe comprising also some Lixi of that author. The relative size and form of the mentum, the mandibles, the presence or absence of wings, the direction of the lateral sulci of the proboscis, in which the first joint of the antennæ is partly lodged, the length of that joint, and the proportions and forms of the thorax—these and other secondary considerations furnish the characters of the various groups. The *Curculionites Longirostres* are divided into two principal sections, in accordance with their habits, and the composition of their antennæ. These consist, in the *Phyllophagi*, of not fewer than ten joints, the last three of which, at least, form the terminal club. But among the *Spermatophagi* the antennæ never consist of more than nine joints, of which the last or the last two form the club. The legs of the Phyllophagi are sometimes contiguous and sometimes remote. Those in which they approach each other are divided into four tribes:—the *Lixides* (Lixus, Fab.), the *Rhynchœnides* (Rhynchænus, Oliv.), the *Cionides* (Cionus, Clairv.), and the *Orchestides* (Orchestes, Illig.). The *Spermatophagi*, again, form three principal sections or sub-tribes:—the *Calandrœides* (Calandra, Clairv., Fab.), the *Cossonides* (Cossonus, Clairv.), and the *Dryopthorides* (Dryopthorus, Schœn., Bulbifer, Dej.). These latter lead to the *Hylesini*, Fab., and other Xylophagi. (See *Règne Animal*, t. v. p. 69.) A great proportion of the European Curculionidæ are most accurately described by Gyllenhal in his *Insecta Suecica*. Mr Kirby's paper on the genus *Apion* (Linn. Trans. vol. iv.) is also deservedly esteemed. The reader will find a critical and expository treatise on this family by Latreille, under the term RHYNCHOPHORES, of the *Dict. Class. d'Hist. Nat.* t. xiv. p. 584. He may also consult Germar's *Insectorum Species Novæ*, and the continuation of Illiger's *Magazin für Insectenkunde*. The British species are described, with their usual skill, by Messrs Curtis and Stephens. The latter, in the second edition of his *Nomenclature*, enumerates above 500 indigenous species. The Scottish kinds are described in our *Entomologia Edinensis*. We see, from our recent correspondence, that about 3000 species of this great family are now known to naturalists.

[2] *Abbildungen zur Anatomie der Insecten.*

[3] *Introduction to Entomology*, vol. iv. p. 107.

visible, filiform, or larger at the extremity. These insects compose the old genus *Bruchus*, Linn. They are subdivided as follows.

Those species of which the antennæ are clavate, or very obviously enlarged at their extremity, with the eyes unemarginate, and which appear to have five articulations to the four anterior tarsi, form the genus Rhinosimus, which Latreille, in accordance with its tarsal characters, formerly placed among the Heteromera, but which other natural affinities connect more closely with the following genus. Those of which the antennæ and eyes resemble the last, but which present only four tarsal articulations, compose the genus Anthribus[1] of Geoffroy and Fab. (Pl. CCXXXIX fig. 16), to which Latreille adds the *Rhinomacers* of Olivier. These insects are generally found on old wood, although some occur on flowers. In the genus Bruchus properly so called[2] (Pl. CCXXXIX. fig. 17), the antennæ are filiform, frequently serrated or pectinated. The eyes are emarginate. The anus is exposed, and the hind legs are frequently very large. These species deposit their eggs in the yet tender germs of our leguminous plants, of our most valuable grains or palms, coffee, &c., where the excluded larvæ occasion infinite damage. The perfect insect detaches a portion of the epidermis in the form of a cap, and, on issuing, produces those circular holes so often seen on peas and beans. Such is a small species called *B. pisi* (see the figure last referred to), an insect which has been known to occasion great injury in North America. A very large species, the *B. Bactris* of Linn. occurs in Cayenne, where it feeds on the fruit of *Cocos guinensis*. It is named *Counana* by the natives. The genus Rhœbus of Fischer is distinguished from the preceding by flexible elytra and bifid hooks to the tarsi. The genus Xylophilus of Bonelli is characterized by clavate palpi.

In the other tribes there is no apparent labrum. The palpi are very small, inconspicuous to the naked eye, and of a conical form. The anterior prolongation of the head represents a beak or trunk.

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Sometimes the antennæ are straight or not geniculate (*Orthoceri*), inserted on the rostrum, and consist of nine or ten joints.

Those in which the three or four last joints are united into a club form

Tribe 2d, Attelabides, Lat.

They gnaw the leaves and tender parts of plants. Most of the females roll up these leaves into a tube or trumpet, in which they deposit their eggs,—thus forming a proper nidus for their offspring. The different proportions of the trunk, the mode of its insertion, the nature of the tibiæ, and the form of the abdomen, have given rise to the formation of several genera, such as Apoderus,[3] Attelabus,[4] Rhynchites,[5] and Apion.[6] The first is very strongly marked. The head is narrowed behind, or presents a neck-like prolongation, and unites with the thorax by means of a rotule. The muzzle is short, thick, enlarged at the end, a character common to the Attelabi properly so called; but in them, as well as in the other two genera, the head enters into the thorax up to the eyes, and the snout is elongated in the form of a proboscis. In Rhynchites the latter is somewhat widened at the end, and the abdomen is nearly square. In Apion, of which Mr Stevens enumerates ninety-one species as indigenous to Britain, the snout is not widened at the end, and frequently terminates in a point. The abdomen is large or inflated.[7] Here also are placed the genera Rhinotia and Eurhinus of Kirby,[8] and Tubicenus of Dejean (*Auletes*, Schœn.[9]).

Those in which the antennæ are filiform, or in which the terminal article alone forms the club,—in which the muzzle, often longer in the males than in the females, and differently terminated, is always borne in advance,—of which the proportions of the body are usually much lengthened, and in which the penultimate article of the tarsi is bilobed, form

Tribe 3d, Brentides, Lat.[10]

In the genus Brentus properly so called (Plate CCXXXIX. fig. 15), the body is linear, and the antennæ filiform or slightly enlarged towards the extremity, and composed of eleven articulations. There is only one species of Brentus found in Europe, the *B. italicus*, which lives beneath the bark of trees, and generally, according to Savi the younger, of Pisa, in the same domicil with a certain species of ant. They are numerous in South America, and occur there also beneath the bark of trees. The genus Ulocerus, Schœn. resembles the preceding in general form, but the antennæ have only nine articulations, the last of which forms a little club. The last of this tribe is constituted by the genus Cylas, Lat. in which there are ten articulations to the antennæ, the last of which forms an oval club. The thorax seems divided into two knots, of which the posterior, forming the pedicle, is the smallest. The abdomen is oval.

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Sometimes the antennæ are distinctly geniculate (*Gonatoceri*), the first articulation being much longer than the following. These form the genus *Curculio* of Linn. or

Tribe 4th, Curculionites, Lat.

These seem naturally divisible into two lesser groups, according as the antennæ are inserted near the extremity of the proboscis (*Brevirostres* or *Brachyrhynchi*), or further back, either towards the centre, or near the base (*Longirostres*, or *Mecorhynchi*); "mais il n'est pas facile," says Latreille, "de bien determiner leurs limites, et plusieurs genres sont très-ambigues sous ce rapport."[11]

A. Brevirostres.

In the genus Brachycerus,[12] Fab. all the joints of the tarsi are entire, and without brush or pellet beneath. The antennæ are short, not much bent, and present externally only nine joints, the last of which forms the club. These insects are destitute of wings, and their body is very scabrous or uneven. They are characteristic of Southern Europe and of Africa, live on the ground, in sandy soils, and appear very early in the spring. The women of Ethiopia use one species as a sort of amulet, passing a string through its body, and hanging it around their necks.[13]

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1 From ανθος, *flower*, and τρίβω, *I destroy*.

2 From βρύχω, *I gnaw*.

3 From απο, used to augment the sense of the word with which it is used, and δερη, *the neck*, which is much prolonged.

4 From αττω, *to leap*, and λαβη, *seizure*. The name was originally applied by Aristotle to an orthopterous insect.

5 From ῥυγχος, *rostrum*.

6 From ἄπιον, *a pear*, which the insects somewhat resemble in form.

7 See Kirby in *Linn. Trans.* vol. ix.

8 *Ibid.* vol. xii.

9 *Curcul. Disp. Method.* 46.

10 Gen. Brentus, Fab. Curculio, Linn.

11 *Dict. Class. d'Hist. Nat.* t. xiv. p. 594.

12 From βραχὺς, *short*, and κερας, *horn*.

13 Caillaud, *Voyage au Fleuve Blanc*.

In the genus CURCULIO, Fab. almost the whole of the under parts of the tarsi are furnished with short stiff hairs forming pellets, and the penultimate article is deeply divided into two. The antennæ are composed of eleven articulations, or even of twelve, if we count the false one by which they are sometimes terminated. The last form the club. This splendid and extremely numerous genus, although greatly restricted by Fabricius, compared with its vast extent in the system of Linnæus, has been still more circumscribed by authors of the present day. An enormous accession of species having been discovered and described, these have been arranged by Germar, Schœnherr, Megerle, Dejean, and others, into a corresponding variety of generic groups, partly for the sake of convenience, and partly (though not entirely) because the nature of the subjects required such systematic modifications. Latreille's observations have led him to form these Curculiones into two principal divisions.

1*st*, Those in which the mentum, more or less widened superiorly, and more or less orbicular, occupies the entire breadth of the cavity of the mouth, and wholly or nearly conceals the maxillæ,—and in which the mandibles have no very sensible dentations, or merely exhibit a slight sinus underneath the point. The generic groups are as follows. In CYCLOMUS the tarsi (as in genus *Brachycerus*) are unprovided with brushes, and the penultimate articulation is entire, or very slightly notched, without distinct lobes. In this genus Latreille would comprise those named *Crytops*, *Deracanthus*, *Amycterus*, and *Cyclomus* of Schœnherr. The tarsi of all the others are furnished with brushes beneath, and the penultimate joint is deeply bilobate. Some are apterous. In CURCULIO properly so called (Pl. CCXXXIX. fig. 18), the lateral sulci of the proboscis are oblique and directed inferiorly. The anterior legs differ little in their proportions from the following ones. The genus, even thus restricted, comprises an immense number of groups, raised by Germar and Schœnherr to the rank of genera, " dont les caractères," says Latreille, " sont peu importants et souvent très-equivoques."[1] He thinks that at most only those should be detached of which the antennæ are proportionally longer. Among such as have short antennæ, the thorax longitudinal, and forming a truncated cone, the shoulders salient, and of which recent writers have formed the genera *Entimus*, *Chlorima*, and others, we find many noted South American species, of considerable size and exquisite beauty, and which, considered all in all, may be regarded as the most splendid examples of the coleopterous order. Such, for example, is *C. imperialis*, commonly called the diamond-beetle, which (may the scientific reader pardon the digression), inclosed in its little box, and covered by a microscope, has so often exhibited to the wondering gaze of youth hues more gorgeous than are ever seen in after days, when no glass, however potent, can dispel the mists which gather around whatever seemed the brightest and most beautiful of earthly things. The species just named is of a brilliant golden green, with two black longitudinal bands upon the thorax. There are several ranges of impressed or hollow spots upon the elytra, of a beautiful and sparkling green, with intervals of black, presenting the appearance of innumerable emeralds incased in gold and ebony. Such also is *C. regalis*, an insect still of great value, of which in former days a single specimen once sold in Paris for L.25 sterling. It is a good deal less than the diamond-beetle, of a bluish green, with extremely brilliant gold and copper bands upon the elytra. It is found in St Domingo and the island of Cuba. Many others, of almost equal beauty, will occur to the recollection of those who have inspected an extensive collection of foreign insects, and the specific names of *fastuosus*, *sumptuosus*, *nobilis*, and *splendens*, sufficiently attest the unfeigned admiration of the lovers of nature, of that bright attire which distinguishes these favoured creatures.[2] The genus LEPTOCERUS[3] differs from the preceding in having the two anterior legs larger than the following, with the thighs thick, the tibiæ arcuated, and the tarsi often dilated and ciliated. The antennæ are usually long and slender. The thorax is almost globular or triangular, and is scarcely exceeded in width by the abdomen. These insects are very abundant in Brazil, and several analogous species are found in the Isles of France and Bourbon. Some inhabit Africa. Another genus, that of PHYLLOBIUS,[4] comprehends likewise winged species, but in which the grooves of the sides of the proboscis are straight, short, and consist only of a simple fossette. Several of these are extremely common in Britain. Along with the preceding, Latreille combines the genera *Macrorhynus*, *Myllocerus*, *Cyphicerus*, *Amblirhinus*, and *Phytoscapus*, of Schœnherr.

Those Brevirostres in which the penultimate joint of the tarsi is bilobate, but which are apterous, and always destitute of a scutellum, form other sub-genera, such as *Othiorhynchus*, *Omias*, *Pachyrhynchus*, *Psalidium*, *Thylacites*, *Syzygops*, and others.

2*d*, Those in which the mentum is narrowed, and, not occupying the whole of the cavity of the mouth, leaves the jaws exposed on either side. The mandibles, too, are evidently dentated. The club of the antennæ is frequently formed of the last five or six joints.

Some have scarcely more than two teeth to the mandibles. The labial palpi are distinct. The club of the antennæ, rather abrupt, does not commence, except from the eighth or ninth articulation, and is not elongated and fusiform. The body, though frequently oblong, is not of a uniform figure. Several are apterous, with the tarsi unfurnished with pellets, and their penultimate article feebly bilobed. Such is the genus MYNIOPS of Schœnherr, with which Latreille combines *Rhytirrhinus* of that author. Several, likewise apterous, have, like most of the Rhynchophori, the under surface of the tarsi furnished with pellets, and the penultimate article deeply bilobed. They compose the genus LIPARUS, Lat. which comprises several genera of Schœnherr. Such as are winged form two additional genera,—that of HYPERA, Germar, in which the tibiæ have either no hook at their extremity, or but a very small one, and that of HYLOBIUS,[5] in which the

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[1] *Règne Animal*, t. v. p. 78.

[2] Even among our native Curculionidæ there are many species, though of small size, yet of exquisite beauty. The genera *Polydrusus* of Germar, and *Phyllobius* of Schœnherr, frequent the foliage of trees and of herbaceous plants. They excel most of the indigenous Coleoptera in brilliancy of colouring,—produced by a covering of minute scales, the body itself being dull and opake. These scales vary in shape, being often rounded and adpressed to the surface, at other times narrower, and having the appearance of hair. The prevailing colours are green or silvery-green, golden, and coppery, of various shades and different degrees of resplendency,—a considerable range of variation being observable even among individuals of the same species. Green, however, is by far the most common colour, and is no doubt intended to contribute to the preservation of the insect by assimilating it to the objects by which it is usually surrounded. (See *Entomologia Edinensis*, p. 253.)

[3] From λεπτος, *slender*, and κερας, *horn*.

[4] From φυλλον, *a leaf*, and βιος, *life*,

[5] From ὕλη, *wood*, and βιος, *life*.

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hook at the internal extremity is very marked. Among the former, *H. tamarisci* (the type of the genus *Coniatus* of Schœnherr) rivals in its colours the most beautiful of the exotic species; among the latter we may name a well-known Scottish insect, *H. abietis*, Linn. (*Cur. pini* of Marsham[1]).

Others have from three to four teeth upon the mandibles, the mentum abruptly narrowed near its upper extremity, and truncated, the palpi very small or imperceptible. The antennæ terminate gradually in an elongated fusiform club. The body has in most an analogous form. Olivier placed these insects in the genus Lixus, from which, in fact, they do not greatly differ. They compose the genus Cleonus, as constituted by Latreille.

B. Longirostres.

In this, the second group of the tribe Curculionites, the antennæ are inserted beyond the origin of the mandibles, and often near the centre of the proboscis, which is usually elongated. It comprises, with the exception of a few species, the genera *Lixus*, *Rhynchænus*, and *Calandra* of Fabricius. In the two former the antennæ are composed of at least ten articulations; they frequently consist of from eleven to twelve, of which at least the last three form the club.

The genus Lixus of Fab. (Pl. CCXXXIX. fig. 19) almost resembles *Cleonus* in the organs of manducation, the elongated fusiform club of the antennæ, the long and narrow form of the body, and the curvature of the tibiæ. *L. paraplecticus* (the species figured) is nearly linear. Its larva lives in the stem of *Phellandrium aquaticum*, and is alleged by Linnæus to occasion *paraplegia* among horses. The disease, as well as the plant, is called Staikra by the Swedes. The transformations of the insect are described by Degeer. Another species, *L. odontalgicus*, is a reputed cure for toothach.

The genus Rhynchænus of Fab. does not present an equal uniformity of character among its constituent parts, and has therefore been numerously subdivided. We shall mention a few of the modern groups.

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In some the legs are contiguous at the base, and there is no sternal groove for the reception of the proboscis. Of these a certain number never leap; their antennæ are composed of eleven or twelve joints, and their body is furnished with wings. Such are the genera Tamnophilus,[2] Bagous (small insects found in marshes), Brachypus,[3] Balaninus[4] (remarkable for the great length of the proboscis), Rhynchænus properly so called, and Sybines. Along with these may be placed Myorhinus of Schœnherr, and other genera, distinguished from the preceding by being apterous. In the genus Cionus the antennæ consist of from nine to ten joints. The body is usually very short, and almost globular. The ensuing differ from those above named in having very thick posterior thighs, which give the faculty of leaping. Those in which the antennæ are inserted on the proboscis form the genus Orchestes[5] of Illiger (Pl. CCXXXIX. fig. 20); those in which they originate between the eyes, that of Ramphus[6] of Clairville.

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In other Fabrician Rhynchæni the legs are remote at the base, and the sternum frequently exhibits a more or less extended cavity for the reception of the muzzle, and even sometimes for that of the antennæ. Those in which that sternal groove does not exist are formed by Latreille into two sub-genera, Amerhinus and Baridius. Those in which it does exist have been formed by Schœnherr into a great many genera, reduced to the following by Latreille, viz. Camptorhynchus, Centrinus, Zygops, Ceutorhynchus, Hydaticus, Orobitis, Cryptorhynchus, and Tylode.[7]

The last of the Longirostres have generally nine articles at most to the antennæ, of which only the last or the last two form the club, which is characterized by a coriaceous epidermis and spongy extremity. These insects live, at least in their larva state, on grain and ligneous substances. They form the great genus *Calandra*, now subdivided into the six following smaller groups.

The first two are apterous, the penultimate joint of the tarsi is bilobed, the antennæ are geniculate and inserted at a short distance from the middle of the trunk. In the first, genus Anchonus of Schœnherr, the antennæ exhibit nine articulations anterior to the short ovoid club, which is formed by the tenth, and perhaps by two others intimately united with it. In the second, Orthochætes of Germar,[8] it is the eighth joint which seems to form the club, although it is probably also of a compound structure. The four following are provided with wings. In the first three the tarsi, in accordance with the almost universal and implied character of the great *tetramerous* section of which they form a part, are all composed of four articulations, of which the penultimate is bilobed. In Rhina, Lat. (*Lixus*, Fab.), the antennæ are strongly geniculate, and inserted near the middle of a straight projecting proboscis,—their eighth joint forming a greatly elongated and almost cylindrical club. The anterior legs are longer than the others, at least in the males. Of this genus we may mention as an example a well-known and singular-looking insect, found in Cayenne and Brazil, called *R. barbirostris*, on account of a thick yellowish-brown beard which envelopes the proboscis of the male, and gives it somewhat the appearance of a bottle-brush. The female wants this kind of garniture on her snout, and she was consequently mistaken by Illiger for a separate species, and named *R. verrirostris*. In the genus Calandra properly so called, the antennæ, likewise strongly geniculate, are inserted near the base of the proboscis,—the eighth joint forming an ovoid or triangular club. The insects of this

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[1] It frequents the Scotch fir, and is common in the Edinburgh district, as well as throughout Scotland. It seems to occur pretty frequently over our southern borders, is more sparingly distributed in Cumberland and the adjoining counties, and, becoming gradually scarcer as we advance, is regarded as a rare insect in the southern parts of England. The imperfect description of this species given by Linnæus, who appears, in some of his works, to confound it with another insect, has rendered it rather difficult to identify his *Cur. Abietis*, and its synonyms have consequently become perplexed. From an inaccurately named specimen in the Linnæan cabinet, Marsham was led to believe that it was the *Cur. pini* of that illustrious observer, and he accordingly described it under that name in his *Entomologia Britannica*. Neither Paykul nor Fabricius appear to have formed accurate views of its characters,—the latter, in his *Species Insectorum*, regarding it as a sexual variety of an insect which in fact belongs to a different genus. The larva inhabits the wood of the Scotch fir, often proving very destructive to young plantations of that tree. The manners of the perfect insect are well described by Linnæus in his peculiar style: "Tarde incedit, arcte apprehendit, tenaciter adhæret, ore frustra cutem mordere tentat captivus."

[2] From ταμνω, or τέμνω, *to cut asunder*, and φίλος, *a lover*.

[3] From βραχυς, *short*, and πους, *foot*.

[4] From βαλανινος, *produced from an acorn*.

[5] From ὀρχηστής, *a leaper*.

[6] From ραμφος, *the beak of a bird*.

[7] For their characters, see *Règne Animal*, t. v. p. 86–7.

[8] *Insectorum Species Novæ*, p. 302.

genus are but too well known for their destructive attacks upon grain, and are included with many others under the vague name of *weevil*. The most noted and injurious species *C. granaria* (*Cur. granarius*, Linn.), is fortunately rare in Scotland, and probably in most other northern countries. But in France and other continental territories it is extremely injurious. This little creature measures about a couple of lines in length, and is generally of a pitchy red, smooth, the thorax deeply punctured. The elytra are rather narrower than the base of the thorax, and do not cover the extremity of the abdomen. They are marked with deep striæ, punctured in the bottom. The legs are ferruginous. It is not in the perfect state that this destroyer commits its ravages. The season for the deposition of the eggs, and the periods of transformation, vary to a certain extent with the temperature of particular seasons; but generally in the south of France, as we are informed by M. Audouin, the female commences her maternal labours about the month of April, and continues them till the autumn. She first buries herself in a heap of grain, to the depth of some inches, and then commences to pierce their envelope, probably by means of a little dart concealed beneath the lower portion of the proboscis. The envelope is then raised, and a small hole bored, either in an oblique direction, or parallel with the surface of the grain. A single hole is made in each grain, and a single egg is laid in each hole, after which the opening is closed by a glutinous matter, so nearly resembling the colour of the grain, that it is extremely difficult to discover which is in a sound state, or which contains the germ of an insidious foe. The injured grains may, however, be detected by their floating when immersed in water, as well as by their feeling lighter when fingered by a practised hand. The egg thus laid is soon hatched, and gives birth to a very minute, white, soft, elongated worm, composed of nine segments, with a rounded corneous head, furnished with two strong mandibles, by means of which it daily enlarges its dwelling, fills its own stomach, and empties the purse of the farmer or grain-merchant. Having attained the term of its increase, it is transformed into a nymph, remains in that state for eight or ten days, and is transformed into a perfect insect, which, piercing the envelope of the grain, ere long produces in its turn a numerous progeny. The influence of temperature, so general on insect life, is effective on this noted *Charanson de blé;* but from forty to forty-five days may be stated as an average term between the union of the sexes and the reproduction of the perfect insect. When the old and unphilosophical belief prevailed of the spontaneous generation of the lower tribes of animal life, it was thought sufficient to say that these weevils were " engendered in the grain by humidity." At an after period it was thought by some who called themselves " observers"—(men of the same class with those who settle all natural phenomena by a paragraph in a newspaper, which they sign " Scrutator"),—that the perfect insect laid her eggs in the green ear, from whence, when the fields were ripe for harvest, they were transported to the stores of the granary. The accurate and inimitable Leeuwenhoeck (*Continuatio Epistolarum*, p. 56) dispelled these errors, and taught us the truth of nature, of which he was ever so great an interpreter. As each larva consumes only a single grain, we may form some idea of their power of increase, from the vast quantity sometimes destroyed. According to the calculation of Degeer, a single pair will produce (among themselves and their descendants), in the course of a season, *twenty-three thousand six hundred* individuals; so that, we may add, a few hundred weevils flying through the grating of a granary, and settling among its treasured heaps, might in the course of four or five months devour or destroy between *one and two hundred millions* of grains. Various modes have been suggested by economists and men of science to stay the progress of these destroyers. We are not sure that any of them have been found very efficacious. The most approved is the following: When the principal body of grain is suspected, let a small heap be placed apart in a corner, and the rest repeatedly stirred about and disturbed. The weevils, which love repose and a quiet life, will leave their usual domicils, and seek about for more peaceful dwellings. An instinct, which the foresight of man in this instance renders unavailing, induces them to settle on the smaller heap, and the shoveling of the main body being continued for some days, a vast number may be thus got quit of. Boiling water is then thrown upon the congregated insects, which have sought refuge in what they deemed a place of safety. As this process destroys only the perfect insects, and not the eggs or larva, neither of which care about being stirred up with any pole, however long, it must be employed during the earliest heats of spring, and before the laying of the eggs. It is said to succeed best when (whatever the principal store consists of) the decoy heap is formed of barley, which, it seems, is a favourite food of weevils. Reduction of temperature by ventilation has also been recommended, as tending to diminish their productive powers; and M. Clement thinks that dryness produced by lime may prove useful, by its tendency to destroy the eggs.[1] Of the larger kinds of Calandra we may mention *C. palmarum*, an insect known to all who have looked into collections of foreign Coleoptera, among which it is extremely common. It is a large species, measuring about an inch and a half in length. It occurs in South America. The larva (figured by Mad. Merian[2]) is named *ver palmiste* by the colonists. It lives in the heart of palm trees, and undergoes its transformations in a cocoon formed of the fibres of those lofty and plume-supporting plants.[3] It is fried and eaten as a great delicacy, both by Indians and Creoles. " C'est probablement," says M. Audouin, " quoi qu'en ait dit Linné, cette même larve, et non celle du Cossus, dont les Romains étaient si friands, et qu'ils nourrissaient avec de la farine." We cannot well see how this could be, unless the new world was known to the Romans, or Italy to the palmist worm. We believe, however, that the Cossus of the ancients was indeed the larva of a beetle (probably of one of the long-horned kinds), and not of a lepidopterous nocturnal insect, or *Cossus ligniperda*, commonly so called.

Our two remaining genera are Cossonus of Clairville and Dryopthorus of Schœnherr (*Bulbifer*, Dejean). In the former the antennæ, scarcely longer than the head and muzzle, have eight joints anterior to the club. They are thick, and inserted towards the middle of the muzzle. In the latter the antennæ have only six joints, of which the last forms the club. In regard to the tarsi the genus presents an anomalous character, and one which, if strictly applied to the definition of the section, would exclude

[1] See *Dict. Class. d'Hist. Nat.* t. iii. p. 28; and *Journal de Physique*, t. lxxxix. p. 358.

[2] *Insectes de Surinam*, pl. 48.

[3] The palm which this insect most affects seems to be one of small size. According to Madame Merian, it grows to the height of a man, and is cut off when it begins to be tender, is cooked like a cauliflower, and tastes better than an artichoke. In its centre live innumerable quantities of larvæ, which at first are as small as a maggot in a nut, but afterwards grow to a very large size, and feed on the marrow of the tree. They are laid on the coals to roast, and are regarded as a " most pleasant food."

it from the tetramerous families. They present five articulations, none of which are bilobed.

FAMILY II.—XYLOPHAGI.[1]

These exhibit a head formed in the ordinary way, without any obvious muzzle, or trunk-like projection. The antennæ are thicker at their extremity, or perfoliated from their base, always short, and consisting in a great number of less than eleven articulations. The joints of the tarsi are usually entire, but with the penultimate enlarged and heart-shaped in some, in which case the antennæ always terminate in a club, either solid and ovoid, or trifoliate, with the palpi small and conical. These insects mostly live and feed in wood, from which habit they derive their family name; and their larvæ are often destructive to timber, in consequence of the ramified perforations which they form in all directions beneath the bark. They frequently so abound in forests of fir and pine, as to render in a few years an immense number of trees entirely useless for all the purposes of human art. Others are extremely injurious abroad to the olive plantations, while several feed on mushrooms. Latreille divides them into three sections.

1*st*, Those of which the antennæ have at most ten joints, and are sometimes terminated by a strong club (generally solid, in others composed of three elongated leaves), sometimes form from their base a cylindrical and perfoliated club; the palpi conical. The anterior tibiæ of the greater number are dentated, and armed with a strong hook; and the tarsi, of which the penultimate article is frequently bilobed or heart-shaped, are capable of being bent or folded on them.

Some have very small palpi, the body convex and rounded above, or almost ovoid, with the head globular, sunk into the thorax, and the antennæ terminated by a solid or a tri-lamellar club, preceded by at least five joints. These Xylophagi compose the old genus SCOLYTUS[2] of Geoffroy, which Linnæus did not distinguish from *Dermestes*. They now form the genera HYLURGUS, Lat., HYLESINUS,[3] Fab., SCOLYTUS proper (Pl. CCXXXIX. fig. 22) of Lat., CAMPTOCERUS, Dejean, PLOIOTRIBUS and TOMICUS, Lat., and PLATYPUS, Herbst.[4] Of many of these each female deposits numerous eggs, and 80,000 wood-eating larvæ have been calculated to inhabit a single tree.

Others have the palpi large and obvious, and of unequal length. Their body is depressed, narrowed in front; their antennæ are sometimes apparently only bi-articulate, with the last joint very large, flattened, almost triangular or ovoid, and sometimes consist of ten joints, entirely perfoliate. The labrum is large. The elytra are truncated, and the tarsi short, with all the articles entire. These insects are all exotic, and compose the genus PAUSSUS of Linn.[5] It has been greatly increased in recent times, and is now divided into several genera.[6]

2*d*, Those of which the antennæ consist of only ten articulations, and of which the palpi, at least the maxillary ones, do not taper gradually to a point, but are of equal thickness throughout, or dilated at the extremity. The joints of the tarsi are always entire. The constituent groups form two principal genera, according to the mode in which the antennæ are terminated. Thus, in BOSTRICHUS the three terminal joints form a perfoliated club. These insects however form four lesser genera, viz. BOSTRICHUS proper (e. g. *Dermestes capucinus*, Linn.) (Pl. CCXXXIX. fig. 24, PSOA, Fab., CIS, Lat., and NEMOSOMA, Desmarets. The second principal genus, called MONOTOMA, is distinguished by the solid and button-like form of the tenth articulation of the antennæ, and is likewise further divisible into four minor genera,—SYNCHITA, Helw., CERYLON, Lat., RHYZOPHAGUS, Herbst, and MONOTOMA proper.

3*d*, The Xylophagi of the third division have eleven very distinct articles to the antennæ; the palpi vary, being filiform or thickened at the extremity in some, more slender at their termination in others. All the joints of the tarsi are entire. Among the LYCTI the club of the antennæ consists but of two joints. They form the genera LYCTUS[7] proper, DIODESMA, Meg., BITOMA, Herbst. Among others the last three or four joints of the antennæ form the club, or the last alone is larger than the preceding ones. In the MYCETOPHAGI, Fab. the mandibles are covered, or project but little. In Latreille's arrangement they form the following seven genera:—COLYDIUM and MYCETOPHAGUS (proper),[8] Fab., TRIPHYLLUS, Meg., MERYX, Lat., DASYCERUS,[9] Brongniart (Pl. CCXXXIX. figs. 26 and 28),[10] SYLVANUS, Lat., and LATRIDIUS, Herbst. The species of the last-named genus are exceedingly minute, none of them exceeding a line and a half in length, and several, being scarcely half that size. They occur in houses, vaults, cellars, &c. and are not unfrequently found beneath the bark of trees. From their habits they are called lurking beetles (Lauerkäfer) by the Germans. Their generic name (from *Lateo?*) has probably the same signification. The larvæ are somewhat egg-shaped and elongate, consisting of twelve segments of a dirty white colour, the antennæ and legs clear as water, with a black line along the back, and a tuft of hairs on the sides of each segment. They live for a longer or shorter period in this condition, according to the state of the temperature and supply of food; the usual time is from four to six weeks. They then change into nymphs of a transparent white, with brownish-yellow eyes, from which, in about fourteen days,

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[1] From ξυλὸν, *wood*, and φαγος, *eating*. [2] From σκολίοτης, *tortuosity*. [3] From ὑλη, *wood*, and σινω, *I injure*.

[4] For their characters see *Règne Animal*, t. v. p. 91–2, and the works there referred to.

[5] The genus *Paussus* did not exist in the twelfth edition of the *Systema Naturæ*, but was published by Linnæus in a separate dissertation in 1775. Only a single species appears to have been known at that period (Mr Westwood now describes above twenty), and another was added in 1796 by Dr Adam Afzelius, then residing at Sierra Leon (*Linn. Trans.* vol. iv.). The etymology of the name is supposed by Afzelius to be from the Greek παυσις, signifying a pause, cessation, or rest; for Linnæus, now old, infirm, and sinking under the weight of age and labour, saw no probability of continuing any longer his career of glory. "He might therefore," adds Dr Shaw, "be supposed to say, 'Hic meta laborum,' as it proved in reality, at least in regard to insects—Pausus being the last he ever described." (*Gen. Zoology*, vol. vi. p. 43.) It was literally, in the language of Young, "An awful *pause*, prophetic of his end."

[6] See an elaborate and learned Essay *On the Paussidæ, a family of Coleopterous Insects*, by Mr J. O. Westwood, *Linn. Trans.* vol. xvi. p. 607.

[7] From λυγτος, *smooth or polished*. [8] From μυκητος, *moss*, and φαγος, *eating*. [9] From δασυς, *hairy*, and κερας, *horn*.

[10] We have figured the type of the genus, *D. sulcatus*, on the plate above referred to. This singular little insect was discovered by M. Alex. Brongniart on a fungus in the forest of Montmorency. It is extremely small, and it is difficult to count the articulations of the tarsi, even with the aid of a good microscope. These parts consist, however, of only three articulations (see fig. 31), which would remove the genus from the tetramerous section, were it not allied to the above genera by other natural characters. The first two joints of the antennæ (see fig. 21) are globular, the following ones very small, capillary and pilose, and the last three or four also pilose and globular.

emerge the perfect insects.[1] We have about a dozen species in Britain.[2] In the TROGOSITÆ,[3] Olivier and Fab. (*Platycerus*, Geoffroy), the mandibles are entirely exposed, salient and robust. The body is generally elongated, narrow, and depressed. In some of these the antennæ are shorter than the thorax, or at most of equal length, and terminate in a compressed club, a little toothed or serrated, and formed by the three or four last articulations. The ligula is entire. In TROGOSITA proper the mandibles are shorter than the head, and crossed. The maxillæ have but a single lobe. *T. mauritanica* (*Tenebrio mauritanicus*, Linn.), about four lines in length, blackish above, light brown beneath, with striate elytra, occurs in nuts, bread, and beneath the bark of trees. The larva, known in Provence under the name *Cadelle*, attacks grain. Here follow the genera PROSTOMIS of Lat. and Passandra of Dalman.

FAMILY III.—PLATYSOMA.[4]

This group of tetramerous Coleoptera approaches the preceding so far as relates to the internal structure, the tarsi, and the habits; but the antennæ are of equal thickness throughout, or more slender towards their termination. The mandibles are always projecting; the ligula is bifid or emarginate; the palpi are short, and the body depressed and lengthened, with the thorax nearly square. These insects are found beneath the bark of trees, and are reduced by Latreille to the CUCUJI of Fabricius, which he distinguishes as CUCUJUS proper (Pl. CCXXXIX. fig. 21), DENDROPHAGUS, Gyll. and ULEIOTA, Lat.

FAMILY IV.—LONGICORNES.

The insects of this family, which in the system of Linnæus formed the genera *Cerambyx*, *Leptura*, and *Necydalis*, have the under surface of the first three articles of the tarsi garnished with brushes, the second and third being heart-shaped, the fourth deeply bilobed, with a little swelling or nodule resembling an articulation at its base.[5] The ligula, borne upon a short and transverse mentum, is generally membranous, heart-shaped, emarginate or bifid,—in others corneous, and forming the segment of a very short and transverse circle. The antennæ are filiform or setaceous, generally at least as long as the body, sometimes simple in both sexes, sometimes serrated, pectinated or flabelliform, in the males. The eyes of a great number are reniform, and surround the antennæ at their base. The thorax is in the form of a trapezium, narrowed anteriorly in such as have the eyes rounded, entire, or slightly emarginate; in which case also the legs are long and slender, and the tarsi lengthened. M. Leon Dufour has remarked that the Longicornes, in regard both to the alimentary tube and the disposition of the hepatic vessels, generally resemble the Melasoma, and, contrary to the opinion of M. Marcel de Serres, he denies the existence of a gizzard. The alimentary canal, usually beset with papillæ, is preceded by a crop, which is smaller and less distinctly marked in Lamia and Leptura, the concluding genera.

The larvæ of almost all the Longicornes live in the interior or beneath the bark of trees. They are either apodal, or provided with very inconspicuous legs. Their body is soft, whitish, largest anteriorly, with a squamous head, furnished with strong mandibles, but without any other projecting parts. They are extremely destructive to the larger forest trees, piercing them to a considerable depth in all directions. A certain number gnaw the roots of plants. The abdomen of the female, in the perfect state, is terminated by a tubular and corneous oviduct. Several species produce a sharpish sound by rubbing a portion of the thorax against the pedicle which attaches the base of the abdomen. Lister calls this sound *querulous*, while Dumeril compares it to the braying of an ass. It is on account of this peculiarity that *Prionus coriarius* is known in Germany by the name of the *Fiddler*. Of this numerous and graceful family some are nocturnal, and frequent old woods and the trunks of ancient trees; others occur on flowers and among flowering shrubs and hedges, and are richly gilded and adorned with various colours;—while all are remarkable for their elongated bodies, their lengthened limbs, and their long and delicately formed antennæ. Several of the species are among the very largest of the coleopterous tribes. The deficiency of wood in our northern quarter of the island is a circumstance unfavourable to the frequent occurrence among us of these lovers of "forest scenery." Even of the English species commonly so called, a few of the finest are probably not original inhabitants of Britain, but have rather been accidentally imported in the larva state in foreign timber, and have afterwards, when excluded in the perfect form, contrived to wing their way, and colonize among our native woods. Their characteristic position is in countries adjoining the equator (especially in South America), and they seem to diminish both in size and number in proportion to their distance from the torrid zone. Britain in general, and more especially Scotland, are considerably to the north of the limit where these insects cease to be common; and in other respects our island presents few local peculiarities at all adapted to their increase. Yet the indefatigable Mr Stephens enumerates about one hundred indigenous species of Longicornes, including, however, certain genera, such as *Trogosita* and *Cucujus*, which Latreille and others do not admit among the long-horned tribes.

According to the system by which we are at present guided, the Longicornes are divisible in the first place into two sections.

A.

Eyes either emarginate or crescent-shaped, or elongated and narrow. Head sunk into the thorax as far as the eyes, without any neck-like restriction,—and vertical in many.

a.

In some the articulation of the palpi is in certain cases nearly in the form of a cone, or reversed triangle; in others nearly cylindrical, and truncated at the extremity. The terminal lobe of the maxillæ is straight (not curved upon the inner one at its extremity); the head generally projected or simply inclined, and when, by a rare exception (as in *Dorcacerus*), its position is vertical, its breadth then nearly equals that of the body, and the antennæ are distant at their base, and spiny. The thorax, often unequal or square, is rarely cylindrical. They are subdivisible into two lesser tribes as follows:

TRIBE 1ST, PRIONII.

Distinguished by the labrum being absent, or extremely small and indistinct; the mandibles strong, or even very

[1] For a more detailed account, see Germar's *Magazin der Entomologie*, vol. ii.

[2] Stephens' *Nomenclature*, col. 32.

[3] From τρωγῶ, *I gnaw*, and σιτός, *corn*.

[4] From πλατος, *breadth* or *flatness*, and σῶμα, *body*.

[5] Latreille remarks, that in regard to the above character, the *Parandræ* perfectly resemble the Longicornes; and that hence, if we consider the little nodule as a genuine joint, both our present family and that which follows might be regarded as pertaining to the great pentamerous section.

Coleoptera Tetramera.

large among the males, and the internal lobe of the maxillæ small or imperceptible. The antennæ are inserted near the base of the mandibles, or of the emargination of the eyes, but are not surrounded by them at their origin. The thorax is most frequently trapezoidal or square, and notched or dentated on the sides.

In the genus Parandra of Lat. the antennæ are simple, almost granose, compressed, of the same size throughout, and at most as long as the thorax; and the ligula is corneous, in the form of a short segment of a circle, transverse, and without emargination. The body is depressed, and parallelopiped, with the thorax square, rounded at the posterior angles, and without any teeth or spines. These tribes are peculiar to America. In Spondylis, Fab. (*Attelabus*, Linn.) the antennæ and maxillary lobes resemble those of the preceding; but the ligula, as in all the ensuing Longicornes, is membranous. The thorax is almost globular, without margins, and unarmed with teeth or spines. The species, which are few in number, inhabit Europe, and their larvæ occur in trees of the pine tribe. In the genus Prionus[1] of authors (Pl. CCXXXIX. fig. 33), the antennæ are longer than the head and thorax,—serrated or pectinated in some,—simple, attenuated towards the extremity, and with elongated articulations, in others. The terminal lobe of the maxillæ is at least as long as the first two articulations of the palpi. The body is generally depressed, with the body square or trapezoidal, and either toothed or spiny, or presenting a lateral projecting angle. These insects are said to take wing only during the night or evening. When reposing they occur on trees. Some exotic species are remarkable for their great size, and their projecting mandibles. " C'est dans ce genre," observes M. Guerin, " qui sont les plus grands Coléoptères connus, puisque certaines espèces Américaines atteignent plus de six pouces de longueur."[2] The larvæ of *P. cervicornis*, which dwell in the wood of the Gossampinus, are used as articles of food. We have only four or five species of this genus in Europe, of which *P. coriarius* is the sole British species. It is one of our largest insects, measuring about fifteen lines in length. The larva lives in the decaying trunks of oaks and birch trees. It undergoes its metamorphosis under ground. *P. giganteus* is above half a foot in length. It fortunately inhabits Cayenne.

Tribe 2d, Cerambycini.

In these the labrum is very apparent, and extends across the entire width of the anterior extremity of the head; the two maxillary lobes are very distinct and projecting; the mandibles are of ordinary size, and similar, or differing but slightly, in the two sexes. The eyes are always emarginate, and surround, at least in part, the base of the antennæ, which are usually the length of, or longer than, the body. The thighs, at least the anterior four, are commonly in the form of an ovoid club, restricted to a pedicle at the base.

Latreille commences with such as have the last articulation of the palpi always obviously thicker than the preceding ones, and in the form of a triangle or reversed cone. The head is not sensibly narrowed, and prolonged anteriorly in the form of a muzzle; the thorax is not widened from before backwards, and does not present the figure of a trapezium or of a truncated cone; the elytra are neither very short and squamiform, nor abruptly narrowed a little beyond their base, and subulate at the extremity. These may be termed the *regular Cerambycini*, in contradistinction to those of a more anomalous nature, by which we shall be afterwards conducted to another tribe. They compose the genera *Cerambyx*, *Clytus*, and *Callidium* of Fabricius, and a portion of his *Stenocori;* and consist of the great Linnæan genus *Cerambyx*, with the addition of some *Lepturæ* of the Swedish naturalist. Certain modern entomologists have greatly augmented the number of generic groups; but Latreille regards the characters assigned for their distinction as by no means sufficiently precise. We shall here notice the principal genera, as admitted in the *Règne Animal.*

A considerable amount of species, all from South America, have the body proportionally shorter and broader than those that follow, and are remarkable for the extent of the thorax, which nearly equals half the length of the abdomen. The anterior legs at least are distant at their base. The scutellum is large in several species. The antennæ are often pectinated, serrated, or spiny. Those of this division, of which the thorax, nearly semi-orbicular and always very large, is smooth or merely chagrined, with a single tooth on either side at the posterior angles,—of which the posterior extremity of the præsternum is plane, truncated, without emargination, or emarginate, and placed upon the mesosternum,—of which the scutellum is always very large, and the legs distant at their origin—form the two following genera:—Lissonotus of Dalman (Pl. CCXXXIX. fig. 35), in which the antennæ are strongly compressed, serrated or semi-pectinated, and long, with the posterior extremity of the præsternum unemarginate:—Megaderus of Dejean, in which the antennæ are simple and shorter than the body, and the posterior extremity of the præsternum emarginate, and receiving the opposing end of the mesosternum. Those, again, of which the thorax is extremely unequal, tubercular, or with many dentations, and the præsternum carinated or terminated posteriorly in a point, form the following four genera,—Dorcacerus,[3] Dejean, Trachyderes, Dalman (Plate CCXXXIX. fig. 37), Lophonocerus,[4] Lat. (Plate CCXL. figure 1), and Ctenodes, Olivier and Klug.[5]

In other groups of species, the thorax, sometimes square or cylindrical, sometimes orbicular or nearly globular, is very much shorter than the elytra, at least in those in which it is extended in breadth, and the præsternum presents neither a carina nor pointed prolongation at its posterior extremity. The scutellum is always small, and the legs are approximate at their origin. Several, remarkable for their beautiful metallic colouring, and the agreeable odour which they exhale, exhibit rather an anomalous character in regard to the relative proportions of the palpi,—the maxillary being smaller than the labial, and even shorter than the terminal lobe of the maxillæ, which frequently projects. The body is depressed, with the anterior of the head narrow and pointed. The hinder tibiæ are often much compressed. They form the genus Callichroma[6] of Latreille (*Cerambyx*, Fab. Dejean). A species well known in England, but which we have not traced farther north than Westmoreland, and remarkable for its strong odour of roses, is the *Cal. moschata* (*Cer. moschatus* of Linn. and of the English naturalists). It measures about an inch in length. South America, and the equatorial regions of the ancient continent, furnish several species. Other Longicornes of this division, but in

[1] From πριον, *a saw.*

[2] *Dict. Class. d'Hist. Nat.* t. xiv. p. 282.

[3] From δορκας, *a goat* or *antelope*, and κερας, *horn.*

[4] From λοφος, *a tuft*, and κερας, *horn.*

[5] For the characters by which these genera are distinguished from each other, see *Règne Animal*, t. v. pp. 111–12.

[6] From καλος, *beautiful*, and χρωμα, *colour.*

which the maxillary palpi are as usual at least as long as the labial, and surpass the extremity of the maxillæ, are distinguished from such as follow, by the antennæ, particularly of the males, having twelve distinct articulations instead of eleven. These parts are always long, setaceous, and not unfrequently spiny or bearded. The thorax is toothed or spiny on the sides. These are united by Latreille under the genus ACANTHOPTERA[1] (*Callichroma, Purpuricenus, Stenocorus*, Dej. Dalm.). Certain species with the thorax nearly square or cylindrical, and the elytra generally terminated by one or two spines, enter into the genus *Stenochorus* of Dalman. Others, more characteristic of the western countries of the ancient continent, form the genus *Purpuricenus* of Ziegler and Dejean. An elegant insect of a pale ashy blue, with three black spots on each elytron, and several joints of the antennæ furnished with tufts of hair, is the *Acanth. alpinus* of Lat. recently removed from the genus Callichroma. It smells strongly of musk. We took it among the Alps of Switzerland, and have since received a specimen captured in a timber-yard in Paris.

The following Cerambycini have only eleven articulations to the antennæ.

In some these organs, at least in the males, are long and setaceous; the terminal article of the palpi is in the form of a reversed cone; the thorax is either square or a little dilated in the middle, or oblong and almost cylindrical; it is often rugose or tuberculated laterally. They compose the genus CERAMBYX properly so called[2] (Plate CCXL. figure 2). Of these, certain species form the genus *Hamaticerus* of recent writers. Such is *C. heros* of Fab. an inhabitant of the temperate and warmer regions of Europe. It is one of the largest Coleoptera of the European continent. The larva forms deep excavations in the wood of the oak, and has been deemed by some the *Cossus* of the ancients. As it is not now the custom to eat grubs, that disputed question still remains obscure. Latreille places in this niche of the entomological system various Callichromæ (so called) of Dejean, with a smooth or but slightly unequal thorax. Most of them belong to South America. They are in general beautifully ornamented by the hand of nature, though their size is small. Some are singularly distinguished by one or more little globular tufts of hair upon the antennæ, and even the hind legs of certain species are similarly adorned. The thighs of these insects (some of which were arranged by Fabricius and Olivier among the *Saperdæ*) resemble a club-like mass, supported upon a more lengthened pedicle. The antennæ consist of long and slender articulations. In the genus GNOMA of Dejean the thorax is long and cylindrical. The palpi are almost filiform, and the inner side of the mandibles presents a tooth. The species occur in America.

In the extensive genus CALLIDIUM[3] of Olivier, the antennæ are in general scarcely longer than the body, and are rather filiform than setaceous. The thorax, always unarmed, is sometimes nearly globular or orbicular, sometimes more narrow, nearly cylindrical, and simply dilated and rounded in the centre. The palpi, always very short, are terminated by an article rather thicker and broader than the preceding ones, and in the form of a reversed triangle. These insects now form the genera CERTALLUM of Megerle and Dejean, CLITUS of Fabricius, and CALLIDIUM properly so called. Of the second and last we have several British species.

Latreille concludes our present tribe of insects with certain species, which, in regard to the palpi, the form of the head, thorax, and elytra, and their general proportions, offer some remarkable and anomalous characters. He commences with such as present a thorax analogous to that of the preceding, especially the genus *Certallum*. It is as broad as the head, and as the base of the elytra, or scarcely narrower, and is either almost cylindrical, or rounded, or nearly orbicular; in both cases wider near the middle. The terminal articulation of the palpi is sometimes attenuated near the end, and terminated in a point, sometimes thicker and truncated, and obconical. All the thighs are clubbed, and supported by an abrupt, slender, and lengthened pedicle. The elytra of the greater number are either very short, or abruptly narrowed at a little distance from their base, and then subulate.

In the genera OBRIUM of Megerle, and RHINOTRAGUS of Dalman, the elytra do not exhibit those peculiar forms; but in Necydalis, Linn. those parts are either very short and scale-like, or prolonged, as usual, as far as the extremity of the abdomen, and abruptly contracted a little beyond their origin, then greatly narrowed, and terminated in a point. They do not resemble the ÆDEMERÆ, with which they were arranged by Fabricius, except in the form of the elytra. They are divisible into two minor groups. For example, those with subulate elytra form the genus STENOPTERUS[4] of Illiger (Plate CCXL. figure 5), while such as have them short and squamiform continue to bear the name of NECYDALIS (ibid. fig. 3).

Certain insects, for the most part proper to the African islands, to New Holland, New Ireland, and New Zealand, present some ambiguous characters; and, according to Latreille, ought perhaps, in a natural order, to be placed between the Lamiariæ and the Lepturetæ. In the mean time, however, he concludes with them the tribe Cerambycini. The palpi are almost filiform, with the terminal articulation nearly cylindrical, slightly attenuated towards the base. The thorax is usually smooth, or but slightly uneven, without acute tubercles, is widened posteriorly, or presents the form of a trapezium or of a truncated cone. The abdomen is almost in the form of a reversed triangle in the greater number, and the elytra are truncated at the extremity. They form four genera, viz. DISTICHOCERA, Kirby, TMESISTERNUS, Lat., TRAGOCERUS, Dejean, and LEPTOCERA of the last-named author.

b.

In other Longicornes, forming

TRIBE 3D, LAMIARIÆ,

The head is vertical and the palpi filiform, or scarcely larger at their extremity, and terminated by an article more or less ovoid, and tapering to a point. The exterior lobe of the maxillæ is a little narrowed at the extremity, and curved upon the inner division. The antennæ are most frequently setaceous and simple, and the thorax, exclusive of the lateral tubercles or spines, is nearly of an equal width throughout. Some species are apterous,—a character not exhibited by any other division of the family.

Our present tribe, in the system of Latreille, is composed of the genera *Lamia* and *Saperda* of Fabricius, of some of the *Stenocori* of that author, of the *Colobotheæ* of Dejean, and of several of his *Cerambyces*.

The genus ACROCINUS of Illiger is constituted by an insect of a very striking and extraordinary aspect, the *Cerambyx longimanus* of Linn. The genus is distinguished

[1] From ακανθα, *a spine*, and πτερον, *a wing*.

[2] From κερας, *horn*, and βους, *an ox*.

[3] From καλος, *beautiful*, and ιδεα, *form*.

[4] From στενος, *narrow*, and πτερον, *wing*.

from all the Longicornes by the thorax being provided on each side with a moveable tubercle, terminated by a point or spine. The body is flattened, with the thorax transversal; the antennæ are long and slender; the anterior legs much longer than the others, especially in the males; and the elytra are truncated at the end, and terminated by two teeth, of which the exterior is the strongest. The singular species above named, of which the colours present an agreeable mixture of grey, red, and black, is known to the French colonists by the name of the *Harlequin* of Cayenne. It is a very large insect. The *Prionus accentifer* of Olivier pertains to the same genus.

All the other Lamiariæ are referable to the great genus Lamia (Plate CCXL. figure 4), which, however, has been extensively subdivided in modern times. A great number of species, chiefly from South America, of which the legs are robust and the tarsi much dilated, fall under the genus Acanthocinus of Megerle and Dejean. Not more than three species are known in Europe. Of these we received *A. ædilis* (called the *Carpenter* in France), from a wood near Inverness; and Sir Thomas Dick Lauder informs us that he likewise took it in a forest of that northern county. Specimens from the neighbourhood of Kirkaldy are preserved in the collection of Sir Patrick Walker. The species is remarkable for the great extent of the antennæ, which in the males are four times the length of the body. It is characteristic of northern countries, and most of the British examples have occurred in Scotland. "Habitat frequens," says Linnæus, writing in reference to Sweden, "in linteribus et arborum truncis decorticatis, dum ex his domos struunt ruricolæ, hinc pueris nostris dicitur *Timberman* omnibus notissima species: vulgus hunc lædere religiose apud nos ducet."[1] Others of an analogous form, but of which the antennæ are garnished with hairs, compose the genus Pogonocherus[2] of the same authors. Britain produces four species, of which two occur in Scotland. Certain apterous kinds compose the genus Dorcadion[3] of Dalman. These insects are proper to Europe and the neighbouring countries of Asia. Their antennæ are generally shorter than the body, with their articulations in the form of a reversed cone, which gives them a knotted aspect. A species common on the continent of Europe (*Cer. fuliginator*, Linn.) is almost exclusively confined to calcareous soils.

Other Lamiariæ have the thorax cylindrical, and unfurnished with tubercles or spines. The body is always elongated,—in some almost linear. They compose the genus Saperda of Fab., which has been greatly subdivided. We have several British species, of which we shall here name only *S. carcharias*, an insect about an inch in length, covered with a yellowish ashy down, spotted with black, and the antennæ coloured alternately with black and grey. Its larva lives in the trunk of the poplar, and sometimes proves injurious to plantations of that tree.

B.

In this our second principal section of the Longicornes, forming

Tribe 4th, Lepturetæ,

The eyes are rounded, entire, or scarcely emarginate, and the antennæ are then inserted forwards, or at most at the anterior extremity of that feeble emargination. The head is always inclined, prolonged posteriorly behind the eyes in several, or abruptly narrowed into a neck-like form at its junction with the thorax. This last part is conical or trapezoidal, and narrowed anteriorly. The elytra become gradually narrower from the base. This tribe corresponds to the genus *Leptura* of Linnæus, with the exception of a few species which fall more naturally among the preceding tribes, and also of such as belong to the more modern genus *Donacia*. We shall here notice only a few of the genera which, as native to our own island, are the most likely to interest the British naturalist.

In the genus Rhagium (of which we have three indigenous species) (Plate CCXL. figure 6), the antennæ are simple, and at most not more than half the length of the body. The terminal articulation of the palpi forms a triangular club. The head is large, almost square, with the eyes entire. The sides of the thorax are furnished with a conical or spinous tubercle. In the genus Toxotus[4] the antennæ are at least as long as the body, simple, with the first article much shorter than the head. The eyes are entire, or very slightly emarginate. The body is triangular, or forms a lengthened square, narrowed posteriorly. *T. meridianus* and *chrysogaster* are supposed to be synonymous,—in which case we have probably not more than two British species. In the genus Leptura[5] properly so called, the head is abruptly narrowed immediately behind the eyes, and the antennæ, inserted near the anterior extremity of their inner emargination, are distant at their base. The two usual eminences from which they spring are almost confounded in one plane. The thorax is almost always smooth, or without lateral tubercles. The majority of the genus occur in Europe, and Britain produces about a score. Few of them have yet occurred in Scotland, probably owing to our comparative deficiency in wood. We have met with only one species in the neighbourhood of Edinburgh, *L. ruficollis*.

FAMILY V.—EUPODA.

Some of the component parts of this family are nearly allied to the Longicornes or preceding tribes, while others so much resemble the Chrysomelæ as to have been arranged with the latter by Linnæus. The organs of manducation present the same range of affinities. Thus, among the Donaciæ, the ligula is membranous, bifid or bilobed, as among the Longicornes, and their maxillæ are very analogous to those of the latter; while among the concluding Eupoda the ligula is almost square or rounded, and analogous to that of the ensuing family, called Cyclica. At the same time the maxillary lobes are membranous, or but slightly coriaceous, whitish, or of a yellowish hue; the exterior expands towards the extremity, and has not the figure of a palpus,—a feature which allies our present family rather to that which we have left than to the one which follows. The body is more or less oblong, with the head and thorax narrower than the abdomen. The antennæ are filiform, or gradually enlarge towards the extremity, and are inserted before the eyes. These are in some entire, round, and projecting, in others slightly emarginate. The head is received posteriorly by the thorax, which is cylindrical, or in the form of a transverse square. The abdomen may be called large when compared with the other parts, and forms a lengthened square, or elongated triangle. The articulations of the tarsi, excepting the terminal one, are furnished beneath with little cushions, and the penultimate is bifid or bilobed. The posterior thighs are very large in many species,

[1] *Fauna Suecica.*

[2] From πωγων, *beard*, and κερας, *horn*.

[3] δορκαδιόν, *a small species of deer*.

[4] τοξοτης, *an archer*?

[5] Named from λεπτος, *slender*, and οὐρα, *the tail*, in allusion to the attenuated form of the elytra.

and it is from that character that the family derives its name. They are all winged insects, and occur on the stems and leaves of various plants, especially, so far at least as many of the European species are concerned, on the liliaceous tribes. The larvæ of the Donaciæ feed on the internal portion of the roots of aquatic plants. Those of other genera live exposed, but, after the manner of the Cassidæ, cover themselves with a case or scabbard formed of their own excrementitious matter. Latreille divides the family into two tribes.

TRIBE 1ST, SAGRIDES.

The mandibles terminate in a sharp point. The ligula is deeply emarginate or bilobed.

In some the palpi are filiform, the eyes emarginate, the posterior thighs very large and strong, and the tibiæ arcuated. We here place the genera MEGALOPUS,[1] Fab. and SAGRA properly so called (Plate CCXL. figure 7). The former insects are proper to South America; the latter, although one occurs in Africa, are characteristic of China, and the great eastern islands, such as Java, the Celebes, and Ceylon. Some of the Sagræ are among the richest and most beautiful of the coleopterous tribes. There is something striking in their gigantic limbs, and their colours consist of burnished green and gold, mingled with violet and deep flame colour.

In others the palpi are enlarged at their extremity, the eyes entire, and the thighs of nearly equal dimensions. Such are the genera ORSODACNA of Lat. and PSAMMŒCUS, Boudier.[2]

TRIBE 2D, CRIOCERIDES.

The extremity of the mandibles is truncated, or presents two or three teeth. The ligula is entire, or but slightly emarginate. These insects correspond to the genus CRIOCERIS[3] of Geoffroy, which Latreille divides as follows.

In some the mandibles taper to a point, and present two or three teeth at the extremity. The palpi are filiform, the antennæ of ordinary thickness, almost granose in certain species, and chiefly composed in others of articulations in the form of a reversed cone, or perceptibly thicker towards their superior extremity.

In the genus DONACIA, Fab. (Plate CCXL. figure 8), the posterior thighs are large and inflated. The antennæ are of equal size throughout, and composed of lengthened articulations. The eyes are entire, and the terminal joint of the tarsi is inclosed, for the greater part of its length, by the lobes of the preceding articulation. This interesting genus was confounded with *Leptura* by Linnæus and Degeer, and with *Stenochorus* by Geoffroy. It was established by Fabricius under its present name, from δοναξ, *a reed*, on account of the species of which it is composed being found on reeds and other aquatic plants, such as those of the genus Iris, Saggitaria, Nymphæa, &c. to which they cling with great tenacity, and on the roots of which the larvæ are supposed to feed. In the form of their bodies and antennæ they show an alliance to the Cerambycidæ, but their habits, and the structure of the cibarian organs, ally them still more closely to *Crioceris* and *Galeruca*. They are frequently bronzed or gilded in their aspect, and are covered in some cases by a fine silky down, which is supposed to prove useful to them when they fall into the water. Indeed, even in the perfect state, they are partly aquatic, and may be seen to seek repose and shelter on the under side of the leaf of a water lily, where they are necessarily submerged. According to M. A. Brongniart, the chrysalids are attached to their filaments by one edge only. M. Leon Dufour inclines to think, in consequence of anatomical investigation, that the Donaciæ ought to be formed into a particular family. His observations, as we are informed by M. Latreille, demonstrate that their hepatic vessels, in number, form, structure, and arrangement, constitute a very remarkable exception to those of the Tetramera in general, and one which even appears peculiar to the genus. These vessels only open into the chylific ventricle, while in all the other Tetramera which M. Dufour has dissected, they have two insertions, one of which is ventricular, and the other cæcal. These biliary ducts, which are only four in number, are of two different kinds, —the first are capillary, and disposed in two strongly flexed curves, and are inserted by four distinct ends into a short obround vesicle placed at the inferior and somewhat lateral extremity of the chylific ventricle,—the others are much shorter, thicker, more dilatable, thin, and tapering at both ends, with one extremity free, and separately inserted by the other into the superior and dorsal region of the ventricle. They contain a whitish pulp, which is regarded as an alimentary substance. The œsophagus is capillary, and has no dilatation in the form of crop. The chylific ventricle is beset with projecting papillæ.[4] Britain produces above twenty species of Donaciæ—a great amount, when we consider that Dejean's Catalogue contains only twenty-six in all. The genus may be regarded as characteristic of Europe, for scarcely any occur in other countries, although a few have been collected in America.

The genus CRIOCERIS properly so called, differs from the preceding in the posterior legs being scarcely, if at all, larger than the others. The antennæ become somewhat enlarged towards the extremity, are almost granose, with their articulations not much longer than broad. The eyes are elevated and emarginate, and the posterior extremity of the head forms a kind of neck behind these latter organs. These insects are of small size, their bodies narrow and elongated, and frequently ornamented with lively colours. They live on the leaves of various plants,—Liliaceæ, Asparagi, &c. and occur in gardens and meadows. When seized they produce a sharpish sound, by rubbing the superior extremity of the abdomen against the inferior extremity of the elytra. The larvæ feed on the same plants as those on which we usually find the perfect insects, and are somewhat adhesive or tenacious by means of their six scaly feet. Their bodies are soft, short, and inflated; and they protect themselves in that early state from the action of the sun and the changes of the season, by covering their backs with their own ordure. They occupy a subterranean position in the nympha state. The species are extremely numerous as the genus was originally constituted, but it has been greatly restricted in recent times. Mr Stephens gives seven as the amount of British species. Of these not above three have yet been found in Scotland. *C. asparagi* was taken near Edinburgh by Sir Patrick Walker.

In others the mandibles, instead of tapering to a point, as in the two preceding genera, are truncated. The palpi are terminated by a strongly inflated joint, truncated, with a small angular prolongation, exhibiting the appearance of another joint. The antennæ are slender, and composed of very long and almost cylindrical articulations. Such is the genus MEGASCELIS of Dejean and Lat. (Plate CCXL. figure 9), peculiar to South America.

[1] From μεγαλοπους, *having large feet.*
[2] For their distinctive characters, see *Règne Animal*, t. v. p. 134–5.
[3] From κριος, *a ram*, and κερας, *a horn.*
[4] *Règne Animal*, t. v. p. 136.

FAMILY VI.—CYCLICA.

In this family the first three joints of the tarsi are still spongy, or furnished beneath with pellets, the penultimate joint divided into two lobes, and the antennæ filiform, or a little larger towards the extremity; but the body is usually rounded, with the base of the thorax as broad as the elytra in such (and these are few in number) as are of an oblong form. The exterior division of the maxillæ, in its narrow and almost cylindrical form, and darker colour, presents the appearance of a palpus; the interior division is broader and destitute of a scaly tooth. The ligula is almost square or oval, entire, or slightly emarginate. It appears from the anatomical researches of M. Leon Dufour, that the alimentary canal is at least thrice the length of the body in such of the genera as have been examined; that the œsophagus is usually inflated behind the crop; and that the chylific ventricle, or stomach, is generally smooth, at least throughout a great part of its length. The biliary apparatus resembles that of the Cerambycidæ and other Longicornes, in the number and double insertion of the vessels of which it is composed;—these amount to six, two of which (except in the genus Cassida) are for the most part shorter and more slender. The larvæ have six feet; their bodies are soft, and frequently coloured. They feed, like the perfect insect, on the leaves of plants, to which they adhere by means of a viscid humour. Some enter the earth prior to their assumption of the nympha state, while others undergo that change attached to the plants on which they feed, and partly encompassed by the exuviæ of the larva. The perfect insects are of small size, but they are frequently adorned by brilliant colours and metallic splendour. They are slow and timorous in their general movements, and when attempted to be seized, they closely fold their feet and antennæ, and drop to the ground. Several species are good leapers, and the females are extremely prolific. Latreille divides this family into three tribes, according to the mode in which the antennæ are inserted.

TRIBE 1ST, CASSIDARIÆ.

These have the antennæ inserted on the superior part of the head, and approximate, straight, short, filiform, and almost cylindrical, or increasing gradually towards the extremity. The mouth, situate altogether underneath, and with very short almost filiform palpi, is sometimes arched (cintrée), sometimes partially received into the cavity of the præsternum. The eyes are ovoid or round; the legs contractile and short, with the tarsi flattened,—the lobes of the penultimate articulation entirely inclosing the terminal one. The body being flat beneath, these insects, by the disposition of their tarsi, are enabled to adhere closely to the surface of vegetation, and to remain there immoveable; in other respects the body is generally orbicular or oval, and is margined all round, or overlapped, by the thorax and elytra. The head is concealed beneath the thorax, or is received into its anterior emargination. The colours are extremely varied, and are distributed in the form of spots and radiated markings, in a manner delightful to look upon. The larvæ present a less inviting aspect, and have the instinctive habit of covering themselves with their own excretions.

In the old genus HISPA,[1] of Linn. the body is oblong, with the head entirely free or exposed, and the thorax trapezoidal. The mandibles have only two or three teeth; the external maxillary lobe is shorter than the internal, and the antennæ are filiform, and borne projecting forwards. These insects now form the genera ALURNUS, Fab. (Plate CCXL. figure 10), and HISPA properly so called (ibid. fig. 11).

The genus CASSIDA,[2] Linn. and Fab. (Plate CCXL. fig. 12), is distinguished from the preceding by the orbicular or almost ovoid form of the body, which, however, in a small number is nearly square. The thorax, more or less semicircular, or in the form of the segment of a circle, entirely covers and conceals the head, or incloses it in its anterior emargination. The elytra, often elevated about the region of the scutellum, project over the body. The mandibles are furnished with not fewer than four teeth, and the external maxillary lobe is at least as long as the internal. The name by which the insects of this genus are distinguished was no doubt bestowed upon them on account of a strongly marked character in their structure. The edges of the thorax and elytra overlap and protect the limbs and abdomen on all sides, and the head is also nearly covered and concealed by the prothorax. Many of the species are highly ornamental, and present pleasing combinations of green and golden hues, which, however, soon disappear or diminish in intensity after the death of the insect, but may be temporarily restored by the use of hot water. These insects are herbivorous in their habits, and are fond of artichokes and thistles. The structure and habits of the larvæ are rather singular, and have been studied and described by Goedart, Roesel, Réaumur, and Degeer. They are flattish, rather broad, and beset laterally by sixteen branched spines placed horizontally on each side of the posterior and superior portion of the body. At the base of these spines may be observed seven small cylindrical truncated tunnels, each placed on a distinct segment. These are probably the stigmatic openings. The head is small, of a corneous consistence, and presents four small tubercles on each side of its superior part, and only three on its inferior. These are regarded by Degeer as genuine eyes. Six scaly feet, terminated by a brown-coloured hook, sustain the body, which is terminated by a two-branched fork, curved over the back, and usually bearing a pile of excrementitious matter, under which the larva lies in part concealed. It can elevate or depress this "stercorareous parasol" at pleasure, for the varying purposes of shade or shelter. The nymph is shorter than the larva, broad, flattened, of an oval form, and surrounded by peculiar appendages. It has an ample thorax, terminated by a circular arch, and furnished with similar points or appendages. The legs and the segments of the abdomen are perceptible. It was in the aspect of one of these nymphæ that Goedart supposed he recognised a representation of the human figure surrounded by an imperial crown. The genus Cassida presents an immense amount of species. About twenty are indigenous to Britain, several more occur on the continent of Europe, and, including exotic species, Dejean enumerates 103 as the amount (in 1821) of his then splendid, and now (1834) unrivalled collection of Coleoptera.

TRIBE 2D, CHRYSOMELINÆ.

In this tribe the antennæ are inserted in front of the eyes, near their internal extremity, and are distant at the base. None of the species are capable of leaping. They form, in the earlier works of Fabricius, the genera *Cryptocephalus* and *Chrysomela*, of which we shall here notice the principal component parts, as modified by the systematic views of recent writers.

[1] Perhaps from *hispidus*, shaggy.

[2] From *cassida*, a helmet.

The original genus CRYPTOCEPHALUS[1] contained those Chrysomelinæ of which the head seemed plunged vertically into an arched or hood-like thorax, in such a way that the body, generally in the form of a short cylinder, or almost ovoid, and narrowed anteriorly, appears, when viewed from above, as if truncated in front, or deprived of the head. The terminal articulation of the palpi is always ovoid.

In some of these the antennæ are short, and pectinated or serrated from the fourth or fifth joint, as in the genus CLYTHRA of Leach and Fab. of which *C. quadripunctata* (a *Chrysomela* of Linn.) may be mentioned as a well-known British species. It measures about half an inch in length, and has red elytra, with a pair of black spots on each. Its larva lives in a little coriaceous tunnel, which it drags along with it. We here place also the singular genus CHLAMYS[2] of Knock[3] (Plate CCXL. figure 13), in which the upper surface of the body is extremely rugged and unequal. Nothing is known of the history or transformations of these insects, all of which, as far as yet observed, are natives of the new world, especially of Brazil, a region so remarkable for its entomological riches. In a state of repose they draw in their legs and antennæ close upon their body, and when not in motion are with difficulty recognised as living creatures. The species are few in number, and by no means common in collections. Mr Kirby has described a new species under the name of *Chlamys bacca*,—" Animal singulare, baccam rubicundam acinis constantem superficie rugoso simulans."[4] In the genus LAMPROSOMA[5] of Kirby (Plate CCXL. figure 14), the body is almost globular, very smooth and convex, and the thorax extremely short, broad, gradually raised, and slightly lobate at the middle of its posterior margin.

In other groups, the antennæ, perceptibly longer than the head and thorax, are simple and filiform, or enlarged towards the extremity, or even terminated by a club,—in which case they are generally toothed like a saw, but only from the seventh joint. In several the body is oval, and narrowed in front. The last article of the antennæ is furnished with an appendage, so as to produce an appearance of twelve joints. In the genus CRYPTOCEPHALUS properly so called, the body is cylindrical, and the thorax as broad as the abdomen throughout its length. The antennæ and palpi are of the same size throughout. We have above a score of species in Great Britain. In the genus EUMOLPUS of Kugelan the body is narrowed in front, and almost ovoid. The mandibles are of ordinary size, and the second joint of the antennæ is shorter than that which follows. Almost all of them are exotic, although a few are found in Europe, of which *E. vitis*, Fab. and certain others, are said to occur in England. According to Geoffroy, the larva of the last-named insect is extremely destructive to vineyards.

We now approach the second great genus of the present tribe, that called *Chrysomela* by Linnæus. Of its modern reconstruction we shall likewise present the reader with a general sketch. The body of these insects is usually ovoid or nearly ovular, with the head salient, projecting or merely inclined. The antennæ are simple, about half the length of the body, and most frequently granose, and insensibly enlarged. When the great Swedish naturalist established his extensive genus Chrysomela, he included within its somewhat too ample boundaries numerous groups, which the more precise observation and richer materials of later entomologists have caused to be erected into separate genera. It is thus that we owe *Erotylus*, *Colaspis*, and *Adorium* to Fabricius, *Eumolpus* to Kungelman, *Helodes* to Paykul, *Doryphora* to Illiger, and *Paropsis* to Olivier,—besides several others, to the origin of which we need not here particularly allude. Many of the species of this genus are among the most beautiful and highly adorned of all the insect tribes. Azure, and green, and gold, form their ordinary costume; and to that lustrous aspect, combined with their compact and rounded forms, they no doubt owe their title of *Chrysomela*, which in the Greek language signifies an apple of gold.[6] These insects are of small or medium size. Few of them measure more than half an inch in length, and the greater number do not equal that dimension. They are strictly herbivorous, and sometimes commit considerable ravages on agricultural and garden produce. The larvæ have in general six feet, an elongated body, beset with warts or tubercles, and terminated by a kind of nipple, which secretes a viscous fluid, used both in walking, and in order to fix the insect firmly before its conversion to the nympha state. Their transformations usually take place in the open air, in which case they are protected by the hardening of their natural envelope. Many of the species are gregarious, while others are solitary; and it is among the latter that such occur as undergo their metamorphoses under ground. We shall now enumerate the principal generic groups into which the old genus Chrysomela has been subdivided.

In some the body is always ovoid, or nearly oval, and furnished with wings; the palpi terminate in a point. These insects resemble the Eumolpi already mentioned, and differ from the ensuing Chrysomelinæ in their filiform antennæ, which are longer than half the length of the body, composed of elongated nearly cylindrical articles, of which the eleventh or terminal bears an appendage or false joint nearly half as long as the article itself. Such are COLASPIS, Fab. which have no projection of the mesosternum; and PODONTIA, Dalman, in which that part projects in the form of a short and conical point, the end of which is received into a posterior emargination of the præsternum.[7]

In the following groups the antennæ are short, composed of articulations in the form of a reversed cone, or more or less nearly granose, and enlarged towards the extremity. The false joint or terminal appendage is very short and indistinct. In the genus PHYLLOCHARIS of Dalman there is no mesosternal projection; but in DORYPHORA[8] of Illiger (Plate CCXL. figure 15), that part is advanced like a distinct horn. The former genus inhabits New Holland and the island of Java,—the latter is peculiar to South America. The genus PAROPSIS,[9] Olivier, or *Notoclea* of Marsham (ibid. fig. 16), is distinguished from all the rest of the family by the maxillary palpi, of which the terminal article is much larger than the others, and hatchet-shaped. These insects, in so far as entomological research has yet extended, seem peculiar to New Holland. The two genera next ensuing interest our native naturalists as abundant over Britain. The terminal article

[1] From κρυπτος, *concealed*, and κεφαλη, *the head.*

[2] From χλαμυς, *a coat of mail.*

[3] *Neue Betrage zur Insectenkunde*, p. 122.

[4] *Linn. Trans.* vol. xii. p. 446. Monographs of the genus *Chlamys* have been published both by Kollar and Klug.

[5] From λαμπρος, *bright*, and σωμα, *body.*

[6] The word *chrysomelum*, from χρυσος, *gold*, and μῆλια, *an apple*, denoted in ancient times a fruit with a yellow rind, and was deemed by Linnæus sufficiently applicable to the insects of our present genus, on account of their rounded form and brilliant colouring.

[7] See Dalman's *Ephemerides Entomologicæ.*

[8] From δορυφορος, *a pike-bearer*, in allusion to the sternal spine.

[9] From παροψις, *a platter.*

of their palpi is also well distinguished from the preceding, to which it is equal, if not larger, in size,—its form being more or less semi-ovoid. These insects are widely spread over most parts of the ancient continent, especially Europe. In the genus TIMARCHA of Megerle and Dejean (Plate CCXL. figure 17), the species are few in number, and apterous. The elytra are joined together, the body gibbous, and the tarsi much dilated, especially in the males. They occur on the ground in woods, fields, and by the sides of highways. Their movements are slow and heavy, and a yellowish or reddish liquor frequently exudes from their articulations. Linnæus classed a well-known species of this genus (*T. tenebricosa*) as a tenebrio. It has been dissected by M. Leon Dufour, and exhibited an intestinal tube three times the length of the body. It presented no appearance of a crop; and the stomach, which was long and folded on itself, contained no sensible papillæ: some small transverse muscular bands were just discernible. The stomach is followed by a filiform intestine, then by an oblong cæcum, bordering on the rectum. As far as our own observation has extended, the species, with a few exceptions from the north of Africa, seem confined to Europe. In the genus CHRYSOMELA properly so called (Plate CCXL. figure 18), the species are all provided with wings, and the terminal article of the palpi is as large or larger than the preceding ones, and in the form of a truncated ovoid, or reversed cone. The species of this delightful genus are extremely numerous, even in its now restricted state. Comte Dejean was many years ago in possession of 120 species, and we know that his collection has recently been much augmented. Even in Britain we possess about thirty species, exclusive of fourteen kinds of *Phædon* and six of *Melasoma*, genera so nearly allied in structure and economy, that some authors do not yet distinguish them from the Chrysomelæ strictly so called. We regret that within our present limits we cannot describe the species. We shall merely mention that we lately received one of the largest and most beautiful, *C. fulgida*, from the valley of Clova in Forfarshire. It was previously unknown in Scotland. Another species of very exquisite aspect, *C. cerealis*, common in France upon the broom, has of late years been taken occasionally in Wales.[1] Our own collection is indebted for it to our liberal friend and valued correspondent the late Mr Melly of Liverpool, a skilful and accomplished entomologist, who possessed one of the largest and probably the best conditioned of the general cabinets of Coleoptera in Britain.

Latreille terminates the tribe with such as have their maxillary palpi attenuated at the extremity, and ending in a point. These form two genera,—PHÆDON of Megerle, in which the body is ovoid or orbicular; and PRASOCURIS of Lat. (Plate CCXL. figure 20).[2] Of the former, *C. fastuosa*, Linn. may be cited as a beautiful example, which occurs in great plenty at the base of Salisbury Crags and other places near Edinburgh, on the *Lamium album* or white dead-nettle,—of the latter, *P. Phellandrii* and *Beccabungæ* are well-known British species.

TRIBE 3D, GALERUCITÆ.

Characterized by the antennæ being always at least half as long as the body, of the same thickness throughout, or insensibly enlarged towards the extremity, inserted between the eyes, at a short distance from the mouth, and usually approximate at their base, and close upon a small longitudinal carina. The maxillary palpi, thickest towards the middle, are terminated by two joints of a conical form, but opposed or united by their base, the terminal one being either truncated, or obtuse, or pointed. The body is sometimes ovoid or oval, sometimes nearly hemispherical. Several, especially of the smaller kinds, have the posterior thighs very large, which gives them the power of leaping. They form the old genus *Galeruca*.

Latreille divides these insects into two principal groups, the *Isopodes*, or such as cannot leap, and the *Anisopodes*, or such as possess that faculty.

To the former belong the genera ADORIUM, Fab., of which the species are foreign; LUPERUS, Geoff., of which we possess two British species; and GALERUCA properly so called, of which our indigenous kinds are more abundant, and which is likewise extremely numerous both in Asia and America. *G. tanaceti* occurs in most parts of Britain. We took it in Sutherland. Java produces a very beautiful species, named *G. albicornis* by Dejean.

To the leaping Galerucitæ belong numerous insects, of which the posterior thighs are much enlarged. They were scattered by Fabricius through the genera *Chrysomela*, *Galeruca*, and *Crioceris*, and have been united by other naturalists under the single genus ALTICA.[3] Though of insignificant dimensions, their colours are varied and brilliant, their movements lively, and their powers of devastation considerable. They feed on the leaves of plants, and are familiarly known by the name of garden fleas. South America produces a great many species.[4] Many subdivisions have been proposed of the old genus just named. Of these, Latreille admits as established groups the genera OCTOGONOTES of Drapiez,[5] ŒDIONYCHIS, DIBOLIA, LONGITARSUS, Lat., and ALTICA properly so called. The last-named genus is the most frequent and best known in Britain. The species are of small dimensions, and occur in great numbers during the spring in humid places, and are extremely destructive both in the larva and perfect state to pot-herbs and other garden produce. The larvæ resemble those of Chrysomela and Crioceris, and some of them are remarkable for discharging an odorous and acid fluid from certain small tubercles on their backs. The nymphæ bear a likeness to those of Coccinella, and remain from fifteen to twenty days in that condition. The perfect insects are often highly adorned, and the species are extremely numerous. We shall mention merely *H. nemorum*, which is oblong-ovate, black, thickly punctured, with a longitudinal yellowish stripe on each elytron, the base of the antennæ, tibiæ, and tarsi testaceous. This species is but too abundant over all our country. "The chief dependence," say Messrs Kirby and Spence, "of our farmers for the sustenance of their cattle in the winter is

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[1] Certain species, of a darker or more obscure complexion than the others, form the genus MELASOMA of Dillwyn, so called from *μιλας*, *black*, and *σωμα*, *body*. We may mention as an example, *M. populi*, the largest of the Chrysomelidæ hitherto found in Scotland. On each of the nine intermediate dorsal segments of the larva of this species there is a pair of black, elevated, conical tubercles, of a hard substance, from all of which when touched it emits a small drop of a white milky fluid, the smell of which, according to Degeer, is almost insupportable, being inexpressibly strong and penetrating. These drops proceed at the same instant from all the eighteen scent organs, which then present a singular spectacle. The precious fluid, however, is by no means wasted when exercised, for each drop, after a momentary appearance, during which it dispenses its perfume, is withdrawn again within its receptacle, till again required. (See Degeer, t. v. p. 291; and Kirby and Spence's *Introduction to Entomology*, vol. ii. p. 246.)

[2] *Helodes* of some other authors.

[3] From *αλτικος*, *a leaper*.

[4] We are indebted to Illiger for a monograph of these insects, published in the *Magazin für Insectenkunde*.

[5] *Annal. des Sciences Phys.* iii. p. 181.

Coleoptera Tetramera.

another most useful root, the turnip; and they have often to lament the distress occasioned by a failure in this crop, of which these minor animals are the cause. On its first coming up, as soon as the cotyledon leaves are unfolded, a whole host of little jumping beetles, composed chiefly of *Haltica nemorum*, called by farmers the *fly* and *black jack*, attack and devour them; so that on account of their ravages the land is often obliged to be resown, and frequently with no better success. It has been calculated by an eminent agriculturist, that from this cause alone the loss sustained in the turnip crops in Devonshire in 1786 was not less than L.100,000."[1]

FAMILY VII.—CLAVIPALPI.

The insects of this family resemble the others of the same section in having the under part of the first three articulations of the tarsi furnished with brushes, and the penultimate bifid,—but they are distinguished from them by their antennæ, which are terminated by a distinct perfoliated club, and by their maxillæ armed on the inner side with a claw or corneous tooth. A few have the articles of the tarsi entire, but they still differ from other Tetramera with analogous tarsi, in their globular or ball-like form. In this family the body is usually rounded, frequently even very convex and hemispherical. The antennæ are shorter than the body, the mandibles emarginate or dentated at the extremity, and the palpi terminated by a large joint; the last joint of the maxillary palpi is very large, transverse, compressed, almost lunate. The form of the organs of manducation indicates that these insects are gnawers; and most of the European species occur on tree fungi, beneath bark, &c.

Some have the penultimate joint of the tarsi bilobed, and are not contracted like a ball. Of these, a certain number have the last article of the maxillary palpi transverse, and almost lunate or securiform. Such are the following genera. Erotylus,[2] Fab. (Plate CCXL. figure 19), in which the intermediate articles of the antennæ are almost cylindrical, and the terminal club oblong. The corneous interior division of the maxillæ is terminated by two teeth. They are peculiar to South America.[3] Triplax (*Triplax*, *Tritoma*, Fab.) differs from the preceding in the antennæ, which are almost granose, and terminate in a shorter and ovoid club. The interior division of the maxillæ is membranous, with a single small terminal tooth. The hemispherical or rounded species form the genus Tritoma of Fab., while those of an oval or oblong shape constitute the genus Triplax of that author.

The remainder of this little group have the last article of the maxillary palpi elongated, and more or less oval. Such are Languria of Lat., of which the species are strangers to Europe; and Phalacrus of Paykul (*Anisotoma*, Illiger and Fab.). The latter genus contains certain small shining hemispherical insects, frequently found on flowers. They pass the winter under moss or beneath the bark of trees, where they probably also undergo their metamorphosis. Their general colours are brown or black; their movements are rapid, and they are with difficulty seized or retained, on account of their smooth and polished surface. They differ from the last-named exotic genus, not only in their general form, but in the club of their antennæ being composed of three instead of five articulations.

In the remaining Clavipalpi all the joints of the tarsi are simple, and the body is almost globular. Such is the genus Agathidium, Illig. so named from *αγαθις*, *a clue*, probably in reference to the faculty possessed by the species of rolling themselves into a ball,—in which state they feign death in the most imperturbable manner. They occur in woods, beneath the bark of trees, and in mushrooms. We regard the genus, of which about a dozen species occur in Britain, as rather characteristic of the north of Europe. It was originally constituted by a dismemberment of Sphæridium, from which, according to the sectional system of Latreille, it stands at a great distance, having, in common with other *Tetramera*, only four articulations to all the tarsi. The same character, in this instance we fear an artificial one, also removes it widely from *Anisotoma*, *Leiodes*, and other genera with which it is, in all likelihood more naturally, conjoined by Mr Stephens and other English entomologists.[4]

Coleoptera Trimera.

TRIMERA.

Three Articulations to all the Tarsi.

This, the fourth primary section of the coleopterous order, consists of three families, of which the first two bear a strong relation to the concluding genera of the section we have just quitted. Their antennæ, almost always composed of eleven articulations,[5] terminate in a club formed by the three last joints. The club is compressed, and in the form of a reversed triangle. The first article of the tarsi is always very distinct; the penultimate is usually bilobed; and the last, presenting a knot at its base, is terminated by a pair of hooks. The elytra are not truncated, and entirely cover the abdomen. The genera of the third family, however, differ from the other two in the characters last mentioned, in which, as in several others, they make an approach to the Brachelytra, and other groups of the great pentamerous section. In their habits also they differ greatly from the rest of the trimerous families.

1st, Fungicolæ.[6]

These have the antennæ longer than the head and thorax, the body oval, with the thorax trapezoidal. The maxillary palpi are filiform, or slightly enlarged at the extremity, but not terminated by a comparatively very large and securiform article. The penultimate joint of the tarsi is always deeply bilobed. The genera are Eumorphus,[7] Weber (Plate CCXL. figure 21), Dapsa, Ziegler, Endomychus,[8] Web. (ibid. fig. 22), and Lycoperdina, Lat.[9]

2d, Aphidiphagi.[10]

Of the great majority of these the body is almost hemispherical, the thorax very short, transverse, nearly lunate. The antennæ terminate in a compressed obconical

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1 *Introduction to Entomology*, vol. i. p. 185.

2 Εϱωτυλος, *amorous* ?

3 See *Monographie du genre Erotyle*, by M. Duponchel, inserted in the twelfth volume of the *Memoires du Museum d'Histoire Naturelle*.

4 For the Scottish species of these, and the allied genera, see *Entomologia Edinensis*.

5 Latreille could clearly make out only nine in those of *Clypeaster*, but he thinks there may be some error in consequence of defective observation, arising from the minuteness of the species.

6 From *fungus*, and *colo*, to inhabit.

7 From ευμοϱφια, *elegance of form*.

8 From ενδομυχος, *concealed within*.

9 See *Règne Animal*, t. v. p. 160.

10 From *aphis*, and φαγος, *eating*.

Coleoptera Trimera.

club, composed of the three last articles, and are shorter than the thorax. The terminal article of the maxillary palpi is very large and securiform, and the penultimate article of the tarsi is deeply bilobed. In the remainder of the family the articles of the tarsi are simple, or at least the penultimate is very slightly bifid, a character which, with certain others, distinguishes these insects from the Fungicolæ.

In the extensive and beautiful genus COCCINELLA, commonly called Lady-birds (Plate CCXL. figure 23), the antennæ are distinctly composed of eleven articulations. The body is nearly hemispherical, the thorax very short, slightly if at all margined, and the penultimate joint of the tarsi is deeply bilobed. The head is not concealed. This genus was established by Frisch, and has been adopted by all succeeding entomologists. It serves, according to Mr Curtis, as a remarkable example of the value of structure in the combination of groups, and of the slight importance of the distribution of colour when employed to distinguish species. "As a genus, Coccinella is so natural that its appellation has never been disturbed; whereas the species composing it are so variable that many of them have been described under a great variety of names."[1]

These insects are distinguishable from the neighbouring genera of *Chrysomela* and *Erotylus* by the number of articulations of the tarsi, which never exceed three. In this character they so far coincide with *Eumorphus*, *Endomychus*, and *Dasycerus*,—but from those genera they differ in the shortness of their antennæ, the form of their bodies, and the development of the last articulation of the maxillary palpi. The general form of these beautiful, and for the most part familiarly-known insects, is hemispherical,—an aspect produced chiefly by the convex shape of the elytra. The under surface is extremely flat, and the legs are short, and, except when the insect is in motion, scarcely project beyond the lateral edges of the elytra. Leon Dufour has illustrated the anatomical structure of this genus with his accustomed accuracy. He discovered in *C. septempunctata* a salivary apparatus composed of three pair of diaphanous vessels, of extreme tenuity, more or less twisted, and extending from the hinder part of the mouth into the abdomen, where the extremities appear to float. He was, however, unable to detect the appearance of any gland or other organ of an essentially secreting nature; but when submitted to a powerful microscope, these vessels exhibited a structure entirely analogous to that of the salivary conduits observable in the dipterous and hemipterous tribes. A linear and tubular axis was perceptible through their pellucid coats, resembling that of the excrementitial secretions of the Carabidæ. The digestive canal is itself scarcely longer than the body of the insect, and is consequently nearly straight. The œsophagus seems inclosed in the head, in such a way that, to render it observable, the alimentary tube must be drawn backwards. The stomach is not preceded by any crop or gizzard. It is bilobed at its origin, where it approaches the head, and receives the œsophagus in the notch or slope produced by that bilobation. It is longer than the rest of the tube,—is very smooth and dilatable,—and was found filled sometimes with a blackish, sometimes with a yellowish pulp. Near its termination were the biliary vessels, six in number. These vessels are somewhat large in proportion to the size of the insect, and each has a distinct and isolated insertion on the stomach, like a cæcum. They have a very varicose aspect, and always appear diaphanous. The insertion of these biliary vessels indicates the limits of the stomach, and we have then a very short intestine, followed by a slightly bulged cæcum, and a rectum distinctly marked.

The larvæ of the Coccinellæ feed on Aphides, and are extremely useful in the destruction of those noxious insects which abound to the deterioration of so many valuable plants. In the perfect state many of the species pass the winter in the clefts of palings and the chinks of walls. Their eggs are usually laid in spring. These are of a yellow colour, with a disagreeable smell, and produce larvæ of an aspect very different from that of the perfect insect. In that early condition the body is much broader than deep, and is pointed towards the extremity, which bears a fleshy projection, carried by the insect on the plane of its position, and serving as a kind of supernumerary foot. The body consists of twelve rings or segments, which in some cases are garnished with spines or tubercles, in others smooth. When the larvæ have attained to their full size, they adhere by their hinder extremity to a leaf or a stone, and partly freeing themselves from a slough or skin, they assume the state of Chrysalis. In the course of a week or two, according to the species, the perfect insect makes its appearance. It is at first soft, flexible, and almost colourless, but a very short period suffices to adorn it with those gay and contrasted markings which render the Coccinellæ or "Lady-birds" among the most admired of all the smaller tribes of coleopterous insects. Some contrariety of opinion appears to exist in regard to the food and habits of these insects in the perfect state. Perhaps their instincts may vary according to circumstances, or may present a disparity in the species. We have frequently observed them preying upon Aphides; and yet Bosc, in describing the *Coccinella borealis* of America, mentions its destructive attacks upon the leaves of the melon plantations; and other species are said to be injurious to the crops of lucerne and cinqfoils. Their numbers vary greatly in different years. In 1807, as Messrs Kirby and Spence inform us, the shore at Brighton, and all the watering-places on the south coast, were literally covered with them, to the great surprise and even alarm of the inhabitants, who were ignorant that their little visitors were merely emigrants from the neighbouring hop-grounds, where in their larva state they had slain their thousands and their tens of thousands of the Aphis, which, under the name of the *Fly*, so frequently blasts the hop-grower's expectations.[2] Mr Stephens enumerates thirty British species of this genus, almost every one of which exhibits several striking varieties.[3]

In the remaining Aphidiphagi the body is very flat, in the form of a buckler, and the head is concealed beneath a nearly semicircular thorax. The antennæ do not seem to consist of more than nine articulations, and terminate in an elongated club. The articulations of the tarsi are entire. The præsternum forms anteriorly a kind of chin-cloth (*mentonnière*). Such is the genus CLYPEASTER, of which the species occur under stones, and beneath the bark of trees.

3D, PSELAPHII.

This little family, in its short and truncated elytra, which leave the abdomen in part exposed, presents a cer-

[1] *British Entomology*, vol. v. f. 208.
[2] *Introd. to Entomology*, vol. i. p. 257; and *Entomologia Edinensis*, p. 293.
[3] The natural union of these apparently distinct kinds may have given rise to the belief that different species of Coccinellæ cohabited with each other. "On trouve quelquefois," says Latreille, "des individus très differents par leurs couleurs accouplés; mais on n'a pas suivi les résultats de ces mélanges." (*Règne Animal*, t. v. p. 162.)

tain resemblance to the brachelytrous tribes, particularly the genus Aleochara.[1] The abdomen, however, is much shorter and wider, and is very obtuse and rounded posteriorly. The antennæ terminate in a club, or are enlarged towards the extremity, and sometimes consist of only six articulations. The maxillary palpi are usually very large. All the articulations of the tarsi are entire, and the first, much shorter than the following, is scarcely perceptible on a cursory examination; the last is frequently terminated only by a single hook. These insects occur upon the ground among vegetable debris. Some are found in ants' nests.

Such as have eleven joints to the antennæ form the genus Pselaphus[2] of Herbst (*Staphylinus*, Linn.), which is thus subdivided by Latreille. A limited number have two hooks to the tarsi. These form the genera Chennium, Lat. (Plate CCXL. figure 25), and Dionix, Dejean. The remainder have only a single hook to the tarsi. Such are Pselaphus proper (ibid. fig. 24) of Lat., Bithynus, Arcopagus and Bryaxis of Leach, and Ctenistes of Reichenbach.[3]

The last of the Pselaphii, and with these we conclude the great coleopterous order, are distinguished by this peculiarity—that the antennæ are composed of not more than six articulations, and in certain cases (genus Articerus of Dalman[4]) apparently of only one. In the genus Claviger[5] (Plate CCXL. figure 26) six joints are quite perceptible (ibid. fig. 27). These insects do not seem to have any eyes. The maxillary palpi are very short, without distinct articulations, and furnished with two terminal hooks. The first two articulations of the tarsi are very short, the third or last very long, with a single terminal hook. These insects occur beneath stones in dry situations.[6]

Order II.—ORTHOPTERA.[7]

In this order the wings are likewise four in number. The elytra or upper pair are softer and more flexible than in the preceding order; they are semi-membranous, reticulated, and for the most part do not form by their junction, when closed, a straight line along the dorsal suture. The true wings are folded longitudinally, and usually after the manner of a fan, and are divided by longitudinal membranous nervures. Maxillæ terminated by a corneous piece, toothed, and protected by the galea, a portion which corresponds to the exterior division of the jaws of coleopterous insects. In this order there is also a kind of tongue or epiglottis. The metamorphosis is semi-complete.

Linnæus arranged the first genus of our present order with his Coleoptera, placing it, however, by itself at the termination of that order;—the remaining genera were grouped with his hemipterous tribes. We owe their separation to Degeer, who formed the whole into an order, under the name of *Dermaptera*.[8] They correspond to the *Ulonata* of Fabricius. The title which they now bear was imposed by Olivier.

The body of orthopterous insects is generally of an elongated form, and of a somewhat soft and fleshy consistence. It is composed as usual of head, thorax, and abdomen. We shall briefly describe the general characters of these parts. The head varies considerably in size, form, and position. It is usually large and vertical, and presents in the greater number of species two or three stemmatic eyes. The front is sometimes prolonged into a conical form, as in certain species of the genera *Truxalis* and *Mantis*; sometimes it bears a kind of fleshy appendix resembling a veil, as in the *Gryllus umbraculosus* of Spain. The true eyes occupy the sides of the head, and are generally very large, with a reticulated aspect. The antennæ do not vary so greatly in their structure as among the Coleoptera, but they are usually composed of a greater number of articulations. They are generally inserted in front of the eyes, but sometimes beneath or between them. Their articulations are not very distinct, and as to shape they are filiform, setaceous, massive, perfoliated, and sometimes ensiform, or resembling the blade of a sword.

The mouth consists of a labrum, two mandibles, a pair of maxillæ, a labium, and four palpi. The labrum is attached to the clypeus by a distinct suture; it is moveable, always external, demi-coriaceous, somewhat arched or vaulted, almost semicircular, rounded in front, and advancing on the mandibles. The mandibles are scaly, or corneous and strong, triangular, short, thick, with the exterior side arched, and the interior armed with many unequal teeth or dentations. According to the observations of Marcel de Serres, these dentations bear a close relation to the mode of nourishment; and he distinguishes them, as we do the dental system of the Mammalia, as *incisive*, *canine*, and *molar*. These last are the largest, and there is never more than one in each mandible, placed towards its base. The three sorts of teeth never exist simultaneously, and it is by their presence or absence, and by the modifications of their forms, that we may recognise the nature of the various substances by which the different tribes of Orthoptera are nourished. In the genera *Mantis* and *Empusa*, for example, which are purely carnivorous, we find only the canine teeth or *laniares*. Those species which have only incisive and molar teeth are herbivorous, while such as are omnivorous possess canine and molar teeth, but of smaller dimensions. The maxillæ resemble in a great measure those of the carnivorous Coleoptera. They are very strong, corneous, at least on their superior portion, which forms a kind of large conical tooth, provided with two or three dentations. They also bear

[1] The *Pselaphidæ* of Mr Stephens form the first family of his *Brachelytra*. (*Nomenclature of British Insects*, 2d edition, col. 89.)

[2] From ψηλαφάω, *to feel one's way*.

[3] For the details of the above genera, of which we can only indicate the names, see Reichenbach's *Monographia Pselaphorum*; the 3d vol. of Leach's *Zoological Miscellany*; the 4th of Gyllenhal's *Insecta Suecica*; the article *Pselaphiens* of the *Encyclop. Méth.*; and the *Règne Animal*, vol. v. p. 164.

[4] Memoir (in Swedish) *On the insects inclosed in amber*, p. 21.

[5] *Claviger*, a club-bearer. See a Monograph of the genus by Müller, in the 3d vol. of Germar's *Magazin der Entomologie*.

[6] Two additional primary sections of the order Coleoptera were formerly recognised, under the names of Dimera and Monomera. These are now suppressed, for the reasons assigned at page 110 of this article.

[7] Ulonata, Fab.

[8] The order now known under the name of *Dermaptera*, and admitted as such by many modern writers, is an osculant one, connecting the *Coleoptera* and *Orthoptera*, and is composed of the genus *Forficula*. The elytra are of a coriaceous consistence, without veins, have a straight suture, and inclose wings which are folded longitudinally as well as transversely. These characters serve to connect it with the preceding order, while the form of the wings, the organs of the mouth, and the nature of the metamorphosis, exhibit its alliance to the orthopterous tribes, along with which we have consequently ranked it in the present treatise, in conformity with the views of M. Latreille, although we are aware that most English entomologists, and many foreign ones, prefer that it should be distinguished as above mentioned.

Orthoptera.

two palpi, but that which is named the internal palpus among the carnivorous Coleoptera is here transformed into a membranous inarticulate piece, sometimes cylindrical, in other instances triangular or dilated, but in all cases vaulted above, and covering the extremity of the maxillæ. It is to this particular portion, or internal maxillary palpus, that Fabricius applied the name of *galea*, or helmet, a term not very accurately translated *galette* by Olivier. The external maxillary palpi, which alone are apparent, are composed of five articulations, of which the two first are extremely short; and it is in these palpi that Olivier and Marcel de Serres suppose themselves to have discovered the organ of the sense of *smell*. The latter author observed in their interior a pair of nerves spreading themselves over the vesicular membrane which terminates their last articulation. These he names the olfactory nerves: one is furnished by the fifth pair, which springs from the inferior face of the brain, and the other by the first pair, which derives its origin from the lateral and superior face of the first ganglion of the head. Between these two nerves there is a trachea, which, before it reaches the vesicular membrane, commences to form a pneumatic pouch. This pouch is more fully developed in the interior of the palpus, and throws off numerous ramifications, which spread themselves within the cavity of the organ. It was this peculiar structure which induced Olivier and Marcel de Serres to regard these palpi as the organs of the sense of smell. We may add, however, that Latreille is by no means satisfied that they are so, and thinks that additional observation is necessary to establish this alleged fact in the physiology of insects. The labium, or ligula, of the Orthoptera, is almost membranous, elongated, slightly enlarged towards its extremity, and divided into two or four stripes or portions.

The interior of the mouth exhibits an additional piece, which some regard as a tongue; it is fleshy, longitudinal, carinated above, broader at its base, slightly restricted before its anterior extremity, rounded, immoveable, and somewhat notched at its point. The mentum is coriaceous, in form of a transverse square, rather narrow towards the summit. The labial palpi are composed of only three articulations, as among the coleopterous tribes.[1] Those of the maxillæ consist of five.

The thorax is composed, as in other cases, of a prothorax, a mesothorax, and a metathorax. The first is generally the largest, and is the only part exposed. It presents a great variety of forms, some of which are sufficiently singular. The elytra, in the greater number, are coriaceous, thin, flexible, semitransparent, and reticulated. They are occasionally almost horizontal, with a straight dorsal suture, as among the Coleoptera; but they are much more frequently more or less inclined, with their inner edges crossing each other when closed over the back. The true wings are broader than the elytra, membranous, full of reticulations, and longitudinally folded after the fashion of a fan. To this latter character, however, the somewhat anomalous genus *Forficula* (containing the earwigs) presents an exception, as in it the wings are also transversely (as well as longitudinally) folded, as among the Coleoptera. In some cases the females, and in a few instances both sexes, among the Orthoptera, are destitute of wings. In many species the elytra of the males are short or rudimentary, and in that sex also a portion of the inner margin of these parts frequently resembles talc or parchment, and exhibits large irregular nervures. It is by the rapid friction of these upon each other that the monotonous song, or *stridulation* as it is called, of many species is occasioned. In others, however, a shrill monotonous cry is produced by rubbing the posterior limbs against the edges of the elytra.

The legs of orthopterous insects are sometimes similar to each other. In other cases the anterior pair are more extensile, and are armed with spines, with which they transfix their prey,—or they are dilated, compressed, strongly toothed externally, and adapted for burrowing in the earth. The posterior legs, as among locusts and grasshoppers, are frequently much larger than the others, and fitted for powerful leaping; and both the middle and posterior pair are more widely apart from each other at their origin than among the coleopterous species. The articulations of the tarsi differ in the different tribes; but we believe that no *heteromerous* species have been yet observed. These articulations are not unfrequently furnished beneath with little membranous cushions, and the terminal articulation is always provided with a pair of hooks or claws.

The form of the abdomen varies in this order. It is divided externally into eight or nine rings, and is often terminated by projecting appendages. Many of the females are furnished with an ovipositor, composed of two portions closely applied, and frequently surrounded by a common envelope.

In relation to the anatomy of the Orthoptera, we may state, that they are all characterized by a first membranous stomach or crop, succeeded by a muscular gizzard, armed interiorly with scales or corneous teeth, according to the species. Around the pylorus, except in the *Forficulæ*, are two or more blind intestines, furnished at their base with many small biliary vessels; and numerous other vessels of a similar nature are inserted towards the middle of the intestine. The digestive system of the larvæ resembles that of the perfect insect.

M. Marcel de Serres has particularly devoted himself to the study of the internal structure of these creatures. He informs us that the Orthoptera with setaceous antennæ, such as the genera *Blatta*, *Mantis*, *Gryllo-talpa*, *Gryllus*, and *Locusta*, have only elastic or tubular tracheæ, and these of two kinds,—the one arterial, the other pulmonary. The latter alone distribute the air to all parts of the body, after having received it from the former. In the genera characterized by cylindrical or prismatic antennæ, such as *Acrydium* and *Truxalis*, the pulmonary tracheæ are replaced by vesicular ones. They are covered by cartilaginous hoops or moveable ribs, and receive air by means of tubular or elastic tracheæ, which proceed from the arterial kind. According to the same authority, the nutritive system is more or less developed, and exhibits four principal modifications. *Gryllus* and *Gryllo-talpa* in that respect excel the others. In them the crop is shaped like a bagpipe, and placed on one side, while in the rest it is on a line with the gizzard. In the latter also the hepatic vessels are inserted insulately, but in the former by means of a common deferent canal. The genera *Truxalis* and *Acrydium* (criquets), although resembling *Locusta* (*Sauterelles*) in their digestive system, differ in respect to the superior hepatic vessels, which are not furnished at their extremity with secreting vessels, and no longer form enlarged pouches, but cylindrical and elongated canals. The intestines of *Blatta* and *Mantis* present only two divisions; their nutritive system is in other respects the same. The *Forficulæ*, of which Mr Kirby and Dr Leach form a distinct order under the title of *Der-*

[1] This characteristic is assigned by Latreille (*Règne Animal*, t. v. p. 168) and other writers; but we have ourselves detected four culations in the labial palpi of several genera.

maptera, do not appear to have been investigated by Marcel de Serres.[1] According to Baron Cuvier, they differ from all other Orthoptera in wanting the superior hepatic vessels.

The metamorphoses of the Orthoptera are called semicomplete, and consist chiefly in the development and increase of the elytra and wings. Both the larvæ and nymphæ feed and move about like the perfect insects, and differ chiefly by the entire want of wings in the first state, and their rudimentary condition in the second. These insects lay an immense number of eggs, of an elongated form and considerable size. They are sometimes deposited in a mass, and inclosed together within a capsule. Both young and old are extremely voracious, and frequently produce the most frightful consequences by their devastations. On the other hand, we are not aware of any recompensing advantages derivable to the human race from any species of orthopterous insects. Several eastern tribes no doubt use them as food, and seem to have done so in remote times, as indicated by the ancient name of *Acridophagi*; and the sacred writings have recorded that the food of John the Baptist in the wilderness was "locusts and wild honey." We believe that no aquatic species is contained in this order.

Mr Macleay has observed, that although there may be reason for hesitation with respect to the types of the Neuroptera, there is none in relation to the principal forms of the orthopterous order. These forms seem to have been perceived by all entomologists, and their dissimilarity has led to tribes being regarded in the light of orders. "Indeed no forms that are within the limits of an order can be more distinct from each other than those of a *Phasma*, *Truxalis*, *Locusta*, *Acheta*, *Blatta*, and *Forficula*; and we accordingly find that they have been considered as the types of so many groups by Linnæus. The affinity of *Blatta* to *Mantis* is acknowledged in the *Règne Animal*. The genus *Proscopia*, lately instituted by Professor Klug of Berlin, one of the first entomologists of the present day, proves the proximity of *Phasma* to *Truxalis*; and no entomologist is ignorant that the chain of connection from *Acridium* to *Locusta*, from *Locusta* to *Acheta*, and from this to *Blatta*, has been long since detected, and is now perfectly established. Hence some notion may be obtained of the contents of the orthopterous circle, if we reckon the above-mentioned five genera as the types of the following tribes:

1. Phasmina.
2. Acridina.
3. Locustina.
4. Gryllina.
5. Blattina.

But as this series returns into itself, and the genus *Forficula* cannot be inserted therein without disturbing its regularity, we must agree with Degeer and Mr Kirby, that it belongs to a distinct order. That this order can only be esteemed osculant between the *Orthoptera* and *Coleoptera*, the reader will perceive by referring to its place in the *Systema Naturæ*. The *Dermaptera*, for so they are termed, from its having been the name originally proposed for the *Orthoptera* by Degeer, are in fact coleopterous insects, with the metamorphosis and caudal appendages of the true *Orthoptera*."[2]

This is a much less numerous order than the preceding, in the amount at least of the ascertained species, and in Great Britain we have not above sixty different kinds.

FAMILY I.—CURSORIA.

All the feet formed for running. Wings and wing-cases almost always placed horizontally on the body. Females unprovided with a corneous ovipositor.

GENUS FORFICULA. Tarsi triarticulate. Wings folded like a fan, and refolded transversely beneath the elytra, which are extremely short, with a straight suture. The body is linear, and terminated by two moveable scaly pieces, in the form of a pair of pincers. Head exposed. Antennæ filiform, inserted before the eyes, and composed of from twelve to thirty articulations, according to the species. The ligula is forked.[3] See Plate CCXLI. figure 3, 4, and 6.

The insects of this genus, known under the familiar name of *earwigs*, are frequent in moist places, beneath stones, under the loose bark of old trees, or in decayed timber. They are injurious in gardens, where they attack various kinds of fruit. They also pierce the petals of flowers, and do not refuse animal food. Our entomological cabinet, when left open for a summer night, has sometimes suffered from their depredations. They may therefore be regarded as omnivorous. Their alleged inclination to enter the *ear* is a vulgar error, not derided however even by the Swedish sage:—"Aures dormientum interdum intrans," says Linnæus, "spiritu frumenti pellenda."

We shall not here describe the species, as their general appearance must be familiar to the reader; but we shall devote a few lines to the manners of the common earwig, *F. auricularia*. The female is known to watch over her eggs with great care,—an uncommon tendency among insects. Degeer placed an earwig, with her eggs, in a box with fresh earth, early in the month of April. They had been scattered by accident about the box; but she soon collected them together, and placed herself above them, as if she were hatching. Towards the middle of May the young made their appearance. They seemed large in proportion to the eggs, and appeared as if swollen. The movement of the dorsal vessel was very perceptible through the skin. These larvæ have neither wings nor elytra. They are composed of thirteen segments, of which the first three bear the legs, and the last exhibits the germ of the pincers, which are conical and slightly divergent. The antennæ are composed of eight articulations. Degeer endeavoured to bring up the young along with their mother, and fed them with slices of apple. They were observed to cast their skins several times, and after each of these changes the antennæ gained an additional articulation. The pincers also became longer, and their points approached each other, as in the adult insect. These larvæ, however, all perished by degrees but one; and the mother also perished, and was found half devoured by her offspring, an ungrateful return for such tender solicitude. This unnatural voracity, however, probably arose from a deficiency of other food, as they are never observed to attack each other in a state of freedom. The remaining larva increased in size, and assumed the nympha state towards the end of July. The cases of the elytra and wings are flat, and closely pressed upon the back, and the pincers have assumed their usual aspect. It therefore does not greatly differ from the perfect insect.

The genus contains many species, and is widely distributed. Several sub-genera have been instituted by Dr

[1] They have since been examined by M. Dufour. See the note of the ensuing page.

[2] *Hor. Ent.* p. 435.

[3] For the details of internal structure of this genus, see the *Mémoire sur l'Anatomie des Labidoures*, by M. Dufour, in the 13th vol. of the *Annales des Sciences Nat.*

Orthoptera.

Leach and others; but the nature of our present article does not admit of our taking cognisance of those minor groups.

Genus Blatta. Tarsi with five articulations. Wings folded only in a longitudinal direction. Head concealed beneath the shield of the thorax. Body oval or orbicular, and depressed. Antennæ setaceous, inserted in an internal notch of the eye, and composed of a great number of articulations. Palpi long. Thorax shield-shaped. (Plate CCXLI. fig. 7

The elytra of these insects are usually as long as the body, coriaceous or semi-membranaceous; and when closed, cross each other a little at the suture. The posterior part of the body is furnished with two conical and articulated appendages. Their crop is longitudinal, their gizzard furnished interiorly with strong hooked teeth, and there are from eight to ten cæca around the pylorus.

The Blattæ, or *cockroaches*, as they are called in this country, are nocturnal insects, which seldom fly, but run with great rapidity. Some inhabit woods or the crevices of old walls, while others frequent store-rooms and dwelling-houses, where their voracious propensities produce great damage to all kinds of provisions. They likewise destroy silk and woollen stuffs, and even leather. But their ravages are chiefly confined to warm countries. The species are numerous. Olivier[1] has described thirty-seven; and many have been discovered since his time. The *Blatta orientalis* of Linn. is about an inch long, of a reddish chesnut-brown. The wings, which are shorter than the abdomen in the male, are merely rudimentary in the female, and are wanting in the larvæ of both sexes. The eggs, to the number of sixteen, are inclosed symmetrically in an oval compressed shell, which is at first white and afterwards brown. It is tolerably solid, and is toothed along its edges like a saw. The female carries it about with her for some time, and afterwards attaches it to a favourable position, by means of a gummy exudation. This species, originally imported from eastern countries, is now widely spread over Europe, and occurs as far north as Finland.

The *Blatta Americana* of Linn. is a native of South America and the Antilles, from whence it was imported into Asia and Africa, and from these to European countries, where it chiefly infests sea-port towns, preying on sugar and other colonial produce. Sonnerat has described its combats with *la Mouche verte*, a brilliant fly of the family of Ichneumonidæ. The thorax of this species is yellowish, with two spots and a border of brown. It may also be known by the great length of its antennæ.[2] Including foreign importations, we have now twelve species of the genus Blatta in Britain.

Genus Mantis,[3] Linn. Tarsi with five articulations. Wings folded longitudinally. Head not concealed. Body narrow and elongated. Palpi short, and ending in a point. Ligula quadrifid.

We may observe, that the genus *Mantis*, as originally constituted by Linnæus, contained a great variety of very singular and somewhat incongruous forms. It has since been greatly restricted, and more precisely defined, by Illiger, Latreille, Lichtenstein, and other modern writers. Thus it is distinguishable from *Empusa* of Illiger, by the antennæ, which in the latter genus are pectinated in the male sex, and by the want of the frontal prolongation of the head. From the spectre insects (*Spectrum*) with which they were likewise combined by Linnæus, the true species of Mantis may be easily discriminated by the form and relative length of the legs, which in the spectres are of uniform size. The head in Mantis is triangular, vertical, with large eyes, and three small distinct stemmata. The antennæ are simple, setaceous, inserted between the eyes, and composed of numerous articulations. The labrum is entire; the mandibles cutting or incisive; the palpi filiform, pointed, not compressed; and the ligula is composed of four parts or divisions of nearly equal length. The thorax is long, and composed almost entirely of the first segment, of which the anterior extremity is frequently dilated, and the sides rounded. The first pair of legs are held in advance and raised, the haunch being very large, and the thigh toothed and compressed; the tibia is also toothed, and terminated by a strong hook or crotchet. The other legs are slender, simple, and unarmed with teeth or spines. The elytra are horizontal, narrow, lengthened, rather thin, semitransparent, and overlap each other on their inner edges. The under or true wings are folded lengthways like a fan. The abdomen is oblong, and is terminated by two conical articulated appendages, and a compressed scaly plate, arched on the back, and composed of several short pieces received into a pair of anal valves.

Such, we conceive, are the characters of the genus Mantis properly so called. It contains a considerable number of species, all characterized by singular and eccentric forms. We do not know by what means it has happened that an insect of this genus has become, in various parts of the world, if not an object of religious worship, at least a subject of superstitious wonder and credulity. From time immemorial the Mantis, in Turkey, has been regarded as a sacred insect; and even among the apathetic Hottentots, so sparingly endowed with any thing allied to the nobler faculties, it is said to be held in still higher estimation. The *Mantis religiosa* of Europe, called *Prega-Diou* (Prie-Dieu) in the southern provinces of France, is well known as living habitually under the safe-guard of a religious veneration on the part of the peasantry, who deem it a faithful guide and guardian of children who have lost their way. It has obtained the name of *religiosa*, from the incessant movements of its fore legs, which it is continually raising into the air, and as it were clasping together. This action, however, is the result of its peculiar instinct and mode of life; for the insect, in common with the rest of the genus, is a fierce, cruel, gormandising creature, and so far from indulging, as is fondly supposed, in a state of religious abstraction, is continually seeking for what it may devour. It preys upon all the weaker insects, which it either crushes to death, or relentlessly impales alive upon the sharp spines of its own shanks. To effect this, it is perpetually moving its arms or fore-legs in the air, and closing one armed joint upon another, so that whatever insect prey approaches within its reach is immediately transfixed and devoured. In some of the French provinces it is called the *sorcerer*. Four or five different species are found in Europe, and many more occur in the warmer regions both of the old world and the new.

In the nymph or intermediate state, the Mantides are as active and voracious as the perfect insect. Following the footsteps of Rossi (author of the *Fauna Etrusca*), the writer of the present treatise has frequently watched their manœuvres on the plains of Pisa, and has more than once had occasion to regret the loss of rarer captures, in consequence of their indiscriminate voracity.

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[1] *Encyclopédie Méthodique*, t. iv.

[2] For the other species, consult Degeer's *Memoires*, t. iii.; *Encyclop. Méthodique*, t. iv.; Fuessly's *Archives des Insectes*, tab. 49, 2–11 Coquebert's *Illust. Icon. Insect.* iii. 21, 1; and the *Horæ Entomologicæ* of M. Toussaint Charpentier, p. 71–78.

[3] From μαντις, *a prophet* or *soothsayer*.

But he cannot say that he ever confirmed the observation of Roesel.[1] On the back of the nymph there are four lamina or flattened cases, which contain the germs of the wings and elytra. The eggs are deposited in a lengthened mass of two rows, and protected by an envelope somewhat of the consistence of parchment. They are of a yellow colour and elongated form, and are usually attached by the female to the stalk of a plant.[2]

Such as have the front prolonged in the form of a horn, and in which the males are provided with pectinated antennæ, form the genus Empusa[3] of Illiger. Their limbs are furnished with rounded membranous appendages resembling ruffles, and in several the edges of the abdomen are festooned. (Plate CCXLI. fig. 1.)

Others have the anterior legs similar to the rest; the stemmatic eyes indistinct or non-existent; the first segment of the thorax shorter or not longer than the following one; the interior divisions of the ligula shorter than the lateral; the antennæ inserted before the eyes, and the head almost ovoid and advanced, with the mandibles thick and the palpi compressed. These form the genus Spectrum,[4] Stoll, which has since been divided into two,[5] both of which are truly remarkable for the singular adaptation of their form and colour to such productions of the vegetable kingdom as they most affect. The sexes often differ greatly. 1*st*, In the genus Phasma[6] of Fabricius (Plate CCXLI. figure 5), the body is filiform and linear, and resembles the stem of a plant or the twig of a tree. Several are entirely apterous, or have extremely short elytra. Very large species occur in the East Indies, the Moluccas, New Holland, and South America. *P. gigas* measures nearly a foot in length. The body is green, tuberculated on the thorax; the elytra very short and likewise green; the wings are large, of a reddish-grey, reticulated, with numerous bands and spots of brown, and with a large lateral space of a coriaceous texture and greenish colour. The legs are spinous. It occurs in the East Indies. *P. Rossi*, a much smaller and apterous species, occurs in the south of France. 2*d*, In the genus Phyllium[7] of Illiger (Plate CCXLI. figure 2), both the body and legs are flattened and membranous, and the first segment of the thorax is cordiform. The wings and elytra vary in their degree of development in the different species, but they frequently cover the abdomen in such a manner as to make it appear as if two leaves had fallen upon the insect. Some seem green and fresh, others brown and withered, while an intermediate kind present the red and yellow hues of autumn. This imitation, or rather representation, of the vegetable kingdom, is indeed so singular as to attract the attention and excite the astonishment of the least curious inquirer; and it is in reference to the peculiar character just mentioned that these insects are known by the name of *walking leaves*. According to some authors, the antennæ of the males are long, slender, setaceous, and composed of a great number of nearly cylindrical articulations,—while those of the females are shorter than the head, conical, granular, and composed of not more than nine articulations. It appears that this great disparity between the sexes led Latreille into an error when he formed a distinct species of *Ph. longicornis*, which is in fact the male of *Ph. siccifolia*. The latter (see the figure last referred to) is fully three inches long, very flat, and of a pale yellowish-green colour. The thorax is short and dentated on the sides, and the foliations of the thighs are likewise dentated. In the female the antennæ are very short, the elytra as long as the abdomen, and the true wings wanting. The form of the male is narrower and more lengthened, and the antennæ long and setaceous; the elytra are short and the wings long. This species, Latreille informs us, is raised by the inhabitants of the Sechelles Islands as an object of entomological commerce. The same species, and some others nearly allied, occur in India, and the great eastern islands, such as Java, the Celebes, &c.

FAMILY II.—SALTATORIA.

Posterior legs very strong, spiny, and formed for leaping.

The males of this family (which corresponds to the great genus *Gryllus* of Linn.) are musical, that is, provided with the power of producing peculiar sounds, by friction of certain parts of their structure upon others. Most of the females deposit their eggs in the earth.

Genus Gryllus. Tarsi with three articulations. Elytra and wings horizontal, the latter folded longitudinally, and forming, when closed, a slender thread-like acumination beyond the elytra. Antennæ setaceous, inserted between the eyes. Ligula with four divisions, of which the central are very small. Labrum entire, with a projecting slip in that of the female.

This genus contains the insects commonly called crickets. They inhabit both fields and dwelling-houses. The common species (*G. domesticus*, Linn.) (Plate CCXLI. fig. 9) is of a pale yellowish or clay colour, mingled with brown. The female bears a long ovipositor, and the male is characterized by his perpetual cry of *cree cree*, uttered most continuously during warm weather, or in the vicinity of ovens or large kitchen fires. These insects remain in their retreats during the day, and come forth in the night season to seek their prey. They feed on bread, flour, and other articles of domestic economy. Latreille says they also devour insects. The common cricket is widely distributed over Europe. In Spain it is kept by the peasantry in little cages hung by the fireside, for the sake of its song.

The field cricket (*G. campestris*) is larger than the preceding. It is of a blackish hue, with the base of the elytra yellowish. The head is large. The posterior thighs are red beneath. The female, during the month of July, lays about three hundred eggs, from which the young are excluded in fifteen days. They feed on herbs and roots, and moult or change their skins before winter. During that inclement season they lie torpid under ground, and re-appear in spring. The larvæ are apterous, the nymphæ bear the rudiments of wings and elytra, the perfect insects, which possess the power of flight, are ma-

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[1] "Il a conservé des Mantes en les nourissant avec des mouches ou autres insectes; quand on les mets ensemble elles se dévorent. Un mâle et une femelle de ces insectes ayant été enfermés dans un vase de verre, le premier fut saisi par la femelle, qui lui coupa la tête. Comme ces insectes sont extrêmement vivaces, le mâle vécut encore assez long-temps, et ne fut dévoré par la femelle que quand celle-ci en eut été fécondée." (Guerin.)

[2] For the species of this and the ensuing genera, see Stoll's *Representation des Spectres, des Mantes*, &c.; Lichtenstein's *Monograph*, in the sixth volume of *Linn. Trans.*; and other works.

[3] From εμπουσα, *an apparition.*

[4] From *spectrum*, a spectre or ideal form.

[5] Other minor divisions have been effected at a still more recent period, by MM. Lepelletier and Serville (in the *Encyclop. Méth.*), and by M. Latreille in his *Familles du Règne Animal.*

[6] From φασμα, *a prodigy.*

[7] From φύλλον, *a leaf.*

nifested in June and July. This species inhabits Africa and all the southern countries of Europe, where the peasant children are in use to *fish* for it, by holding an ant fastened to a hair over its hole. It is foolish and fearless, and will leave its retreat if even a stalk of grass is inserted in its dwelling; hence the French expression of *sot comme un gryllon*. It occurs in England, and we heard its song near Edinburgh for the first time last summer (1833).

There are many very singular insects belonging to this genus. The *Gryllus umbraculatus* occurs in Spain and Barbary. The male is remarkable for a membranous prolongation of the head, which falls over it like a veil. India produces the *G. monstruosus*, of which the elytra and wings are spirally twisted at their extremities. A new and large species has been lately discovered in Sicily by MM. Lefevre and Bibron, and described by them under the name of *G. megacephalus*. Of this insect each particular cry, instead of being momentarily repeated, is prolonged for about half a minute, and may be heard at the distance of a mile.

We shall here briefly notice some of the allied genera. The mole-cricket now forms the genus Gryllo-talpa[1] (Plate CCXLI. figure 8), of which the tibiæ and tarsi of the two anterior pair of legs are flattened and toothed, and so constructed as to serve for throwing back the earth while burrowing. These insects are destructive in gardens and cultivated fields, by detaching or cutting asunder the roots of plants, during the progress of their subterranean excavations. Their natural prey, however, consists of insects and worms. The female of the best known species (*G. vulgaris*, Lat.) lays from two hundred to four hundred eggs in a commodious dwelling under ground, resembling a bottle with a curved neck. The young dwell together for some time in society. The song of the male is sweet and agreeable.[2]

An insect found in the south of France by the sides of rivers, a strong leaper, of small size, and of a black colour, spotted with yellowish-white, belongs to the genus Tridactylus[3] of Olivier, characterized by having the anterior pair of legs only formed for digging. In place of the posterior tarsi, there are moveable appendages in the form of claws. The antennæ are short, of equal thickness throughout, and composed of ten articulations. The species above alluded to is the *Xya variegata* of Illiger. Charpent. *Horæ Ent.* p. 84, t. ii. fig. 2, 5.

A singular species, misnamed *Blatta acervorum* by Panzer, takes up its abode in ants' nests, and now forms a genus of our present group under the name of Myrmecophila.[4] The body is oval and apterous, the posterior thighs very large. In the antennæ, and the want of stemmatic eyes, it resembles *Gryllus* properly so called.[5]

Genus Locusta. Tarsi with four articulations. Elytra and wings inclined. Antennæ very long and setaceous. Mandibles less dentated, and galea larger than in Gryllus. Females provided with an ovipositor compressed in the form of a sabre or cutlass.

These insects are herbivorous. They occur in grassy meadows, and on shrubs and trees. In flying they spring into the air, and then extend their capacious wings, but their flight is neither rapid nor long sustained. The cry of the male is sharp and continuous, and is produced by the friction of the elytra. The genus is extensive, and occurs in many countries. They are usually of a brilliant green. One of the best known in Europe (it is also an English species) is the *L. viridissima*, Lat. (Plate CCXLI. figure 12). It is about two inches in length, of a fine green colour, without spots. The ovipositor is straight, and of the length of the body. Another species (*L. verrucivora*, Fab.) is likewise green, but the elytra are spotted with brown and black. The ovipositor exceeds the length of the abdomen, and is slightly arched. This latter bites pretty severely, and derives its specific name from a practice said to be followed by the Swedes, who allow it to gnaw their warts, which are alleged speedily to disappear, from the action of a black and bilious liquid which escapes from the mouth of the insect during mastication.

Several species are nearly apterous, or present merely scale-like rudiments of the organs of flight, such as the *L. ephippiger*, which now forms a genus under its specific name. Some have the antennæ bearded beneath, with the oviduct shaped like a boat, and form the genus Scaphura of Kirby.[6]

All the preceding genera of the leaping or saltatorial Orthoptera have this character in common, that the males effect their peculiar cry chiefly by a portion of the elytra, which is discoloured, transparent, and somewhat resembles a mirror or small tambourine. But in the following genera, the stridulation of the male is effected by the friction of the spiny legs against the sides and edges of the elytra and wings. The antennæ are sometimes filiform and cylindrical, sometimes sword-shaped, or terminated by a mass, always at least as long as the head and thorax. The ligula in the greater number has only two divisions. There are three simple eyes, the labium is notched, the mandibles much toothed, the abdomen conical and laterally compressed. The tarsi are composed of three articulations, and the female is not furnished with a prolonged ovipositor. They all leap better than the preceding genera, and have a higher and more sustained flight. They feed on vegetables, and are extremely voracious. They compose the old genus *Acrydium* of Geoffroy, which Latreille divides as follows.

*

Mouth exposed, ligula bifid, a membranous cushion between the hooks, at the end of the tarsi. Genus Pneumora. Antennæ filiform, of sixteen articulations, inserted close upon the inner margin of the eye. Posterior legs shorter than the body, and less adapted for leaping. Abdomen large, vesicular, and appearing as if empty.

We know little of the manners of the insects of this genus (Plate CCXLI. figure 14). They inhabit southern Africa, and feed on vegetable substances. The *P. sexguttata* has green elytra, with three silvery spots on each. It is a very beautiful insect.

Genus Proscopia, Klug. Without wings. Body long and cylindrical. Head prolonged anteriorly into a point or cone, bearing two short filiform antennæ, composed at most of seven articulations, of which the last is pointed. Posterior legs large and long, approximated to the intermediate, which are farther than usual from the anterior pair.

These singular insects are peculiar to South America, and are usually of a large size. Klug, in his monograph of the genus, has described fifteen species.[7]

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[1] From *gryllus*, a cricket, and *talpa*, a mole.

[2] For a curious account of the habits of the mole-cricket, see *Nouv. Cours d'Agriculture*, deux ed. t. v. p. 163. Its anatomy is described in *Ann. du Mus. d'Hist. Nat.* t. xx. p. 213.

[3] From τριδακτυλος, *with three fingers*.

[4] *Memorie Scientifiche di Paolo Savi*, Pisa, 1828.

[5] *Règne Animal*, t. v. p. 183.

[6] See also *Règne Animal*, t. v. p. 184; Charpentier's *Horæ Ent.*; and Thunberg in the *Mém. de l'Acad. Imper. de Petersbourg*.

[7] See *Proscopia, Novum genus Insectorum Orthopterorum*, in folio, with two plates.

Genus Truxalis, Fab. Head pyramidal, bearing on its extremity, and above the eyes, two prismatic, compressed, ensiform antennæ.

We are acquainted with about a dozen species of this genus. Their distinctive characters have not yet been well expressed, and it is not improbable that several have been confounded. They are characteristic of the warmer countries of the ancient continent. The best known is the *T. nasutus* of Fab. figured by Roesel, *Insect.* ii. Gryll. iv. 1, 2. See also Drury, ii. xl. 1. It occurs in Africa and the south of Europe (Plate CCXLI. fig. 10).

Genus Acrydium. Head ovoid. Antennæ filiform, or terminated by a button, and inserted between the eyes, at some distance from their inner margin. Body solid, and not vesicular. Hinder legs longer than the body.

This genus contains the noted insects commonly called *locusts,* the structure and history of which we shall briefly detail. The head is largely developed, and supports two rather short antennæ, composed of twenty articulations. The true eyes are oval, projecting, and situated on the sides of the head, while the stemmatic eyes, three in number, form a triangle on its summit. The mouth is composed of a large and broad upper lip, slightly notched on its anterior margin; of strong cutting mandibles, irregularly toothed; of maxillæ terminated by three teeth, and supporting at the same time the galeæ by which they are covered, and a pair of filiform palpi, consisting of five articulations; of an inferior lip, broad, advanced, bifid at the extremity, and giving insertion to a pair of filiform palpi of four articulations. The prothorax, of the same breadth as the body, sometimes exhibits superiorly small *keels,* which are prolonged transversely on the sides in slight impressions, appearing to indicate the natural divisions of that portion of the thorax. The chest of the mesothorax and metathorax, or rather the sternum, is broad, flattened, and very dissimilar to that of *Locusta* (Sauterelles), in which it has the appearance of two triangular foliaceous plates. The elytra are coriaceous, narrow, and as long as the wings, which are large, reticulated, folded like a fan, and frequently ornamented by brilliant shades of red or blue. The legs are of unequal length,—the two anterior pair being of ordinary proportions, while the hindmost are large, and formed for leaping. Many species exhibit on each side, and near the origin of the abdomen, a large cavity, closed interiorly by a thin membranous diaphragm, of a pearly white colour. Latreille regards it as a pneumatic pouch, forming an acoustic instrument. It may no doubt be influential in regulating the sounds uttered by these insects, which, however, are certainly produced in the first place by the alternate friction of the inner face of the hind legs against the surface of the elytra.

The females, which are not provided with an exserted ovipositor, lay their eggs in some instances in the ground, in others on the stalks of plants, to which they adhere naturally by a gummy secretion, and are, moreover, enveloped and protected by a frothy matter, which hardens over them. The larvæ, the nymphæ, and the perfect insects, are all voracious, and feed on plants. The ravages of locusts are so well known to all readers of foreign travels, and accounts of their desolating inroads have been so frequently extracted, and published in numerous popular works, that a few slight notices of the subject will here suffice.

Locusts are of very common occurrence in many parts of Africa. Mr Barrow records, that in the southern districts which he visited, the surface of an area of nearly 2000 square miles might literally be said to be covered by them. The water of a wide river was scarcely visible, in consequence of the innumerable dead locusts which floated on its surface, apparently drowned in their attempts to reach the reeds which grew along its shores. Except these much wished-for reeds, they had devoured every other green thing. Their destruction on a former occasion was sudden and singular. All the full-grown insects were driven into the sea by a tempestuous wind, and were afterwards cast upon the beach, where they formed a bank three or four feet high, and extending *nearly fifty English miles.* The smell, as may be easily supposed, was most abominable, and was sensibly felt at the distance of 150 miles. In regard to the Indian locusts, a correspondent of Messrs Kirby and Spence informed these authors, that he was an eye-witness to an immense army of locusts which ravaged the Mahratta country, and was supposed to come all the way from Arabia. This column extended *five hundred miles,* and was so compact when its members were upon the wing, as to darken the sun like an eclipse, so that no shadow was cast upon the ground, and some lofty tombs, distant not more than two hundred yards from the observer, were rendered invisible. These were not the *Gryllus migratorius* of Linnæus (*A. migratorium,* Plate CCXLI. figure 13), but a red species, the peculiar colour of which is said to have added additional horror to the scene;—for after having stript the trees of their foliage, they congregated around the bare and desolate branches, producing a hue like blood. When they moved again, "the sound of their wings was as the sound of chariots, and of many horses running to battle."

The migratory flight of these insects, their desolating effects upon vegetation, and consequent injury both to man and beast, have afforded a frequent subject of exercise to the pen of the poet; but by none has their injurious inroads been so magnificently portrayed as by the prophet Joel. "A day of darkness and of gloominess, a day of clouds and of thick darkness, as the morning spread upon the mountains; a great people and a strong: there hath not been ever the like, neither shall be any more after it, even to the years of many generations. A fire devoureth before them, and behind them a flame burneth: the land is as the garden of Eden before them, and behind them a desolate wilderness; yea, and nothing shall escape them. The appearance of them is as the appearance of horses; and as horsemen so shall they run. Like the noise of chariots on the tops of mountains shall they leap, like the noise of a flame of fire that devoureth the stubble, as a strong people set in battle array." "The earth shall quake before them; the heavens shall tremble: the sun and the moon shall be dark, and the stars shall withdraw their shining." "How do the beasts groan! the herds of cattle are perplexed because they have no pasture; yea, the flocks of sheep are made desolate."

Dr Southey, "the laurel-honouring laureate," as he is well called by his friend and fellow poet S. T. Coleridge, has also, in his "wild and wondrous lay" of Thalaba, sketched the progress of these destroyers.

> Onward they came, a dark continuous cloud
> Of congregated myriads numberless,
> The rushing of whose wings was as the sound
> Of a broad river headlong in its course
> Plunged from a mountain summit, or the roar
> Of a wild ocean in the autumn storm,
> Shattering its billows on a shore of rocks.

The scene of the above quotation is Arabia, where these insects are very formidable, and of different kinds. Forskal thinks that the species which chiefly infests that tented region, and which he names *Gryllus gregarius,* is distinct from the *Gryllus migratorius* of Linnæus. They come invariably from the east, which induces the Arabs to believe that they are produced by the waters of the Persian Gulf. Nejed is particularly exposed to their ravages; and no sooner have they destroyed the harvests,

than they penetrate by thousands into the dwelling-houses, devouring whatever they can find, even to the leather of the water vessels. They appear in the air at a distance like clouds of smoke; and their near approach, accompanied as by a sound of falling water, stuns the inhabitants with astonishment and dread. They alight upon a field, and its verdure disappears,—the lofty palms are stript of their long shadow-casting leaves,—and pulse and all other succulent crops are voraciously devoured. Grain, however, if ripe, usually escapes, in consequence of its hardness and aridity. The Bedouins of Sinai are frequently driven to despair by the multitudes of these flying vermin, which remain for a period of a month or six weeks before they finally disappear. The time of their arrival is towards the end of the month of May, when the Pleiades are setting,—a coincidence which leads the natives to imagine that locusts entertain a dread of that beautiful constellation. Although a few are visible every year, the great flights are inflicted only every fourth or fifth season. Most of the Arabs, except those of Sinai, are in the habit of eating these insects. "In almost every town there are shops where they are sold by measure. In preparing them, the cook throws them alive into boiling water with which a good deal of salt has been mixed. After a few minutes they are taken out and dried in the sun; the head, feet, and wings are then torn off; the bodies are cleansed from the salt, and perfectly dried, after which they are put up into sacks or bags. Sometimes they are broiled in butter, and spread on the unleavened bread used at breakfast. The Jewish Arabs believe that the food of which the Israelites ate so abundantly in the desert was showers of locusts."[1] They are also used as food in several African countries, and are even exported as articles of commerce. The elytra and wings are first cut off, and then the bodies are preserved in brine. M. Miot, in his translation of Herodotus, has observed that the numerous carcasses of *winged serpents* said to have been noticed in Egypt by the early Greek historian, were in all probability masses of the dead bodies of some large species of locust. Latreille coincides in this opinion.[2]

The most noted species is that already mentioned under the name of *Acrydium migratorium* (*Gryllus migratorius*, Linn.), Plate CCXLI. figure 13. It measures above two inches and a half in length. Its usual colour is green, obscurely spotted, the elytra pale brown, marked with black. The mandibles are likewise black, and the thorax is marked by a slightly elevated crest. This species is common in Poland, but occasionally extends its ravages into other European countries. It was very destructive in Provence so lately as the year 1819. It is well known in the Levant, in Barbary, and Egypt. These countries produce another species, likewise found in the south of France, the *A. lineola*, Lat. It is of a reddish-brown colour. The crest of the thorax is intersected by three impressed transverse lines; there is a conical pectoral point between the anterior legs, almost as long as the haunches; and the posterior legs are furnished with reddish spines, black at their extremity. This species is eaten in Barbary. Another kind, native to Senegal and other parts of Africa, of a yellow colour, spotted with black (it is figured by both Shaw and Denon, in their Travels), is ground when dry into powder, and used as flour. Many large exotic species are characterized by the superior portion of the thorax being greatly elevated, much compressed, and forming a sharp crest, rounded and prolonged backwards to a point. Of this kind, though of smaller dimensions, is the *A. armatum*, found in the south of Europe, and figured by Fischer.[3] Others have the elytra and wings so abbreviated, at least in one of the sexes, as to be incapable of flight. These form the generic group named Podisma by Latreille. Such as exhibit a swelling or button-like expansion at the tips of the antennæ form the genus Gomphocerus of Thunberg;—for example, the *A. sibiricum* (figured by Panzer, *Fauna Insect. Germ.* xxiii. 20), which occurs alike among the desert steppes of Siberia and the mountain passes of St Gothard.

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In this second section of the Acrydium of Geoffroy, a part of the under portion of the head is received into a cavity of the præsternum. The ligula is quadrifid, and the tarsi are unprovided with a cushion between the claws. The articulations of the antennæ do not exceed from thirteen to fourteen. The thorax is prolonged backwards in the form of a large scutellum, sometimes exceeding the body in length. The elytra are extremely small. Such are the characters of the genus Tetrix of Latreille (Plate CCXLI. figure 15), which is composed of a considerable number of small species. A good light has been thrown on their characters and classification by MM. Lepelletier and Serville, in the *Encyclopedie Méthodique*, article *Tetrix*, as well as in the more recent works of Mr Zettersted.[4] The genus contains the little chirping insects so frequent in this country on dry and sunny banks, and known under the familiar name of *Grasshoppers*.

Order III.—HEMIPTERA.[5]

The insects of this order have neither mandibles nor maxillæ properly so called. Their mouth is fitted for suction, and is composed of a tubular articulated rostrum, cylindrical or conical, curved inferiorly, or directing itself along the breast, and, when extended, presenting the appearance along its upper surface of an elongated groove or canal, in which are lodged three delicate pointed bristles, covered at their base by a ligula. These bristles form by their union a needle-like sucker, of which the tubular piece just mentioned forms the sheath, in which they are retained by means of the ligula or triangular basal portion. The inferior bristle is in fact composed of two, which unite together not far from their origin, so that the sucker itself consists of four pieces. Savigny is of opinion that the two superior bristles are analogous to the mandibles, and that the inferior represent the maxillæ[6] of the masticating orders. According to this view, which the author has illustrated with admirable assiduity and skill, the mouth of hemipterous insects is as usual composed of six principal portions, the so-called ligula representing the labrum, and the articulated sheath the labium, of the other orders.[7] According to Latreille, the languette properly so called also exists, and under a form analogous to that of the supposed labrum, but bifid at the extremity. The palpi, however, have entirely disappeared, with the exception of some slight vestiges of those parts observable in the genus *Thrips*. These representative relations between the parts of the mouth in the mandibulated and haustellated orders had in fact been sus-

[1] *Edinburgh Cabinet Library*, vol. xiv. (Arabia, vol. ii.) p. 460.
[2] *Règne Animal*, v. 187.
[3] *Entom. de la Russ.* i. Orthopt. i. 1.
[4] *Orthoptera Sueciæ*, 1 vol. 8vo, Lund. 1821, and *Fauna Laponica*, 1 vol. 8vo, Hamm. 1828.
[5] Ryngota, Fab.
[6] *Mém. sur les Animaux sans Verteb.* i. part i.
[7] See Pl. CCXXXIII. figs. 4 and 6. and the detailed explanation of the same at page 69 (*note* 1) of this article.

Hemiptera.

pected by Latreille previous to their laborious demonstration by the ingenious Savigny.[1]

The elytra of a great portion of the hemipterous order are of a coriaceous texture throughout their principal extent, with their terminations membranous. They thus partake of the nature of both elytra and wings, and the order, as formerly mentioned, derives its name from that peculiarity. Among the Cicadæ and the Aphides, however, all the four wings are membranous, and frequently quite clear and transparent. In *Tettigonia*, *Membracis*, *Flatta*, &c. they are of a denser consistence; while in *Aleyrodes* they are farinaceous, and of a milky translucence. Certain kinds are apterous, as the bed-bug, some species of *Lygæus*, and the females of the cochineal insect,—but these anomalies do not remove them from the hemipterous order, to which the structure of the mouth shows them to belong.

The composition of the thorax in these insects begins to experience some modifications, which exhibit their relation to the ensuing orders. The first segment, or prothorax, in certain cases resembles in extent that of the Coleoptera; but in others it is much more minute, and becomes incorporated with the second segment, which is then manifest or exposed. The scutellum is sometimes extremely small, or altogether imperceptible; while in certain genera, such as *Scutellera* and *Membracis*, it is greatly dilated, and covers the entire upper surface of the body, concealing the elytra and wings.

The sucker, regarded as a sting, and so named by the ancient naturalists, is adapted only for the extraction of animal or vegetable matter in a fluid state. The delicate parts of which it is composed penetrate various organic substances, the nutritive juices of which are forced to flow into the interior canal by successive compressions, till they reach the œsophagus.

The antennæ of the hemipterous tribes are frequently very small, and of difficult detection. In *Psylla*, *Cimex*, *Thrips*, and others, they are very obvious; in *Cicada* they are short, simple, setaceous threads; in *Fulgora* they are still shorter and subulated; while in *Nepa*, *Ranatra*, &c. they are placed beneath the eyes, and so abbreviated as to be rendered visible only by reversing the insect.

The eyes are rather large, and between them, on the upper part of the head, in many species, there are two or three of the stemmatic kind, or ocelli, called *yeux lisses* by the French entomologists.

The nature and amount of the tarsal articulations differ according to the genera or tribes; but the greater number of hemipterous insects are characterized by three divisions of the tarsi. In some the anterior tarsi are composed of only a single piece, which is bent upon the leg in the form of a pincer; while in the aquatic genera, such as *Naucoris* and *Notonecta*, the posterior legs are oar-shaped, with the tarsi composed of two articulations.

All hemipterous insects pass as usual through three stages of mutation. But their metamorphosis is not in any case complete, and their changes consist rather in the development of the organs of flight, and the increased bulk of the body, than in any very decided or obvious transformation. Their anatomical structure exhibits a stomach with a rather solid and muscular coat, a small intestine of medium length, succeeded by a large intestine, divided into various swellings, and of a small number of biliary vessels, inserted at some distance from the pylorus.[2] The habits of the order are extremely various, as we shall show when we come to treat of the genera more in detail.

Hemiptera Heteroptera.

HETEROPTERA.[3]

Sucker originating from the front of the head. Elytra membranaceous at their extremity. First segment of the thorax much larger than the others. Wings horizontal or slightly inclined.

FAMILY I.—GEOCORISÆ.[4]

Antennæ exposed, longer than the head, and inserted between the eyes near their internal margin. The tarsi are composed of three articulations, of which the first is sometimes extremely short. These insects form the great genus CIMEX of Linnæus, which has now undergone many modifications. They are principally *terrestrial* insects, although some dwell upon the *surface* of waters. From several of the species a disagreeable odour emanates.

GENUS SCUTELLERA,[5] Lam. Sheath of the sucker of four distinct articulations. Labrum prolonged beyond the head, awl-shaped, and striated above. Tarsi with three articulations, the first as long or longer than the third. Antennæ filiform, of five articulations. Body usually short, oval, or rounded. Scutellum covering the abdomen. (Plate CCXLII. fig. 1).

The insects of this genus, formed by Lamarck from *Pentatoma* of Olivier, live on plants, of which they absorb the juices by inserting their suckers in the leaves or tender twigs. They occur in many countries, but are larger and more brilliant in equatorial than temperate regions. The *S. nobilis* of Latr. is of an elongated oval form, and of a metallic or golden blue colour, spotted with black. It is found in Asia. The *S. stokerus* is oval, green, spotted with black, and has a red abdomen. It occurs in the Antilles. Of the European species we shall mention only the *S. lineata* (*Cimex lineatus*, Linn.), which is about four lines in length, red, radiated above with black lines, and marked beneath with black spots linearly disposed. It is common in Central and Southern Europe on umbelliferous flowers.[6]

GENUS PENTATOMA,[7] Oliv. Elytra exposed. Scutellum covering only a portion of the body. Other characters as in the preceding genus.

The species of this genus, known as *wood-bugs*, and under other names, are extremely numerous. They occur in every region of the world, and under various temperatures. The species proper to the warmer countries of Africa, America, and the East Indies, attain to a considerable size, and are adorned by brilliant colours. The larvæ of these insects do not greatly differ from the perfect state, except in having neither wings nor elytra. The nymphæ possess these organs in a rudimentary state, inclosed in sheaths. Their changes of condition are accompanied by a general casting of the skin. In their various states they exist on vegetable juices, which they seem as it were to pump up by means of their suckers. Some species, however, have been seen to attack insects, even those of their own kind, and suck their softer parts. Almost all of them exhale a disagreeable and penetrating odour,

[1] *Hist. Nat. des Crust. et des Insect.* t. ii. p. 140–143.

[2] *Règne Animal*, v. 192.

[3] From ἑτεροιος, *of a different kind or nature*, and πτερα, *wings*.

[4] From γη, *the earth*, and κορις, *bug*.

[5] From *scutellum*, a shield.

[6] Consult, for the other species, Fabricius, *Systema Ryngotorum*, genus *Tetyra*.

[7] From πεντα, *five*, and τομα, *division*.

Hemiptera Heteroptera.

which adheres to whatever substance the insect touches. The eggs are deposited on the stalks of plants, regularly disposed, and made to adhere by means of a remarkably tenacious liquid. They are not unfrequently adorned by extremely agreeable colours.

A pleasant and curious narrative is given by Degeer, relating to the female of a species of this genus, the *Cimex griseus* of Linn. He found on a birch tree several of these females, each followed by a little troop of thirty or forty young ones, which accompanied their mother as chickens do a hen. The parents seemed to watch over them with the greatest solicitude. This is a singular fact in the history of insects, which for the most part are not personally regardful of the welfare of their offspring, although they seldom fail instinctively to deposit their eggs in situations the best adapted for the sustenance and preservation of the future larvæ. Several of the generic groups proposed by Fabricius, as derivable from the genus Pentatoma of Olivier, are not adopted by Latreille; while, on the other hand, several genera proposed by more recent writers have been adopted.[1]

Genus Tesseratoma, Pel. et Serv. Antennæ with four articulations. Body very flat, membranous, with the margins much dilated, notched, and angular. Thorax prolonged posteriorly in the form of a truncated lobe. This genus was formed upon the *Edessa papillosa* and *amethystina* of Fabricius. The species are chiefly from India and the Eastern Islands (Plate CCXLII. fig. 2). Certain species from Brazil, and we believe other countries, likewise very flat, with the margins notched and dilated, with the anterior extremity of the body forming a clypeus truncated in front, and cloven at the sides, form the genus Phlæa of the *Encyc. Méth.* (Plate CCXLII. fig. 3).

Genus Coreus,[2] Fab. Antennæ with four articulations, filiform, or larger at the extremity, the last being usually shorter than the preceding. Body oval. Sheath, labrum, and tarsi similar to those parts in the genus Pentatoma, which they resemble in their habits of life.

The species of this genus have the head in general of a trigonal form, and sunk, without apparent neck, into the prothorax, which is narrow anteriorly, and broader behind. The eyes are small, but prominent. The scutellum is triangular and obvious. The elytra equal the length of the abdomen, which is depressed, with elevated edges. The legs are long and slender. These creatures are said by some authors to feed on other insects, as well as on the juices of plants. The *C. marginatus* is of an obscure brown, with two small advanced points between the antennæ. The latter have their second and third articulations fulvous. It exhales a strong smell of apples. Wolff, *Icon. Cimic.* fascic. i. p. 20, t. 3, fig. 20. The *C. hystrix* is an insect of a very bizarre appearance, found in France and elsewhere. Sparmann collected a species not very dissimilar at the Cape of Good Hope,—of a grey colour tinted in parts with reddish brown; spiny, membranous, the edges of the thorax relieved in roundish lobes. The abdomen likewise margined by numerous brown-coloured lobes. The second and third joints of the antennæ are spiny at the extremity. It was named *C. paradoxus* by Fabricius (Plate CCXLII. fig. 4). Between the principal genus *Coreus*, Fab. and that named *Lygæus* by the same author, as now restricted, several intermediate ones occur in the system of Latreille.[3] Of these, however, we shall mention merely the genus *Neides* (Plate CCXLII. fig. 5), distinguished by its greatly elongated and almost linear form of body, and slender limbs and antennæ.

Genus Lygæus, Fab. Antennæ terminated by an elongated article, almost cylindrical, and of the same thickness as the preceding joint. The stemmatic approach the true eyes, and the membranous appendages of the elytra frequently offer only four or five nervures.

The *L. equestris* (Plate CCXLII. fig. 6) is red, spotted with black. The thorax is black before and behind, and there are two points of the same colour on the scutellum. The elytra are traversed by a black band, and there are two small spots and a point of white upon their membranous portion. It measures about five lines in length. The abdomen has four ranges of points. The *C. apterus* (Stoll, *Cimic.* ii. xv. 103) is rather less, red, and without wings. The head, a spot on the centre of the thorax, and a large point on each elytron, are black. The extremities of the elytra are truncated, or without membranous appendages. It sometimes occurs winged. The species with the large anterior thighs have been formed into a separate genus by MM. Lepelletier and Serville. Those with angulated antennæ form the genus Neides of Latr. already mentioned, and the genus Alydus of Fab. includes such as have filiform antennæ without dilatation, and the body narrow and elongated.[4]

All the preceding genera of the Linnæan Cimices agree in having four articulations to the sheath of the sucker, and a prolonged and striated labrum; but those which follow have only two or three apparent articulations to the sheath, and the labrum is short and without striæ. The first joint of the tarsi, and frequently the second also, are very short in the greater number.

a.

Feet inserted in the middle of the chest, and terminated by two distinct hooks, which take their origin from the central extremity of the tarsus. They are not adapted for rowing, or running on the surface of the water.

*

Rostrum straight, more or less inclosed in a sheath. Eyes of ordinary dimensions. Union of the head and thorax not characterized by a narrow neck, or sudden restriction. The body is usually membranous in whole or in part, and is generally extremely flat. This group of genera composes the major part of the primitive genus Acanthia of Fabricius, which the author himself afterwards dismembered.

Genus Syrtis, Fab. Anterior feet formed of a monodactyle claw like that of the Crustacea, and serving them in like manner to seize their prey. Antennæ terminated by an oval mass or enlarged articulation, and lodged in a groove of the head and thorax.

The species of this genus feed on flies and other insects, which they seize with their fore legs, after the manner of the *Mantides*. They live in woods. The *S. crassipes* (Wolf, *Icon. Cimic.* tab. 9, fig. 82) measures about three lines and a half in length. The head and thorax are brownish red; the abdomen of a deeper hue as far as the centre,—the sides and towards the base being paler. The antennæ, under parts of the body, and feet, are reddish yellow. This is a European species. Most of the others occur in South America.

Genus Tingis, Fab. Body extremely flat. Antennæ with the third articulation much longer than the others, and terminated by a button.

These insects live on plants, of which they pierce the leaves and flowers, not unfrequently producing great injury to their vegetation. The species found on the pear-tree, and known to the continental horticulturists under

[1] See *Règne Animal*, t. v. p. 193–4.

[2] From κορις, *bug*.

[3] See *Règne Animal; Encyc. Méthod.* t. x.; and the *Systema Ryngotorum* of Fab.

[4] *Ibid.* and *Genera Crustac. et Insect.* iii. p. 126.

Hemiptera Heteroptera.

the name of *tiger*, is extremely destructive. It is the *T. pyri* of Lat. and is distinguished by a white reticulated thorax, the edges raised, and inflated in the centre. The scutellum is foliaceous. The elytra are white, with two black bands. The larva of *T. clavicornis* inhabits the flowers of *Teucrium Chamædrys*, and, by piercing the petals, causes them to thicken,—thus preventing their healthy development. The puncturings of the perfect insects of this genus sometimes produce a kind of gallnut.

Genus Aradus, Fab. Body formed like that of Tingis; but the antennæ are cylindrical, with the second articulation almost as long or even longer than the third.

These insects occur chiefly on the trunks and beneath the bark of trees, where they congregate during the winter. They show themselves more actively in spring. The *A. corticalis* of Wolff (*Cimic.* fasc. iii. t. ix. fig. 81) serves as a type of the genus.

Genus Cimex, Lat. Resembles the preceding genera in the form of the body; but the antennæ are almost setaceous, composed of four articulations, of which the first is shorter than the others, the second thick and long, the third also lengthened and more slender than the others, the last scarcely increasing in thickness at the extremity. Elytra extremely small. No true wings.

Of this genus the *C. lectularius* or bed-bug (Plate CCXLII. fig. 7) is probably too well known in many quarters to require particular description. It deposits its eggs in the month of May. The larvæ differ from the perfect insects in wanting the elytra. This species, though mentioned by Dioscorides, is said to be not an original inhabitant of Europe. It is also believed to have been unknown in London prior to the great fire in 1666, after which calamity it was transported thither in timber from America. It is said sometimes to acquire wings, and infest young pigeons, swallows, and other birds. Latreille however is of opinion that the kind attached to the last-named birds is of a distinct species from that which troubles the lords of the creation. The best means of extirpating bugs are care and cleanliness.

* *

Rostrum exposed, arched, sometimes straight, but with the labrum projecting. The head suddenly restricted behind, so as to form a neck-like portion.

†

Eyes not remarkably large. Neck apparent.

Genus Reduvius, Fab. Rostrum short, but sharp and piercing. Thorax distinctly lobed. Elytra at least as long as the abdomen. Tarsi triarticulated. Antennæ with four articulations, setaceous, and extremely slender at the extremities.[1]

The species which form this genus are predaceous, and greedily attack other insects, sucking out their juices with their sharp-pointed beaks. The *R. personatus* is about eight lines in length, and of a blackish-brown colour, without spots. It is common in France. This species, which inhabits the interior of houses, covers itself with ordure, or the sweepings of apartments, and, thus disguised, lies in wait in some obscure corner for its prey. No sooner does a fly or other feeble insect approach within a calculated distance, than it suddenly darts upon it, and sucks it to death. Sometimes it may be seen approaching its victim by slow and cautious steps, till the fly, thrown off its guard by this insidious show of peace, is instantaneously captured by one deadly spring. Its bite is so severe as to produce the immediate death of its captive; and indeed we are informed that our venerated friend Latreille having been bitten on the shoulder by a Reduvius, experienced a great swelling of the entire arm, and suffered severe pain for several hours. It is chiefly in the larva and nympha states that these insects disguise themselves in the manner just mentioned. Entomologists are acquainted with a great many species of this genus, few of which, however, are native to Europe. The rest are spread over Asia, Africa, and America.

We shall here briefly notice a few of the genera which in recent times have been formed by dismemberment of the genus Reduvius as originally constituted by Fabricius. In the genus Heloptilus of Lepel. et Serv. the antennæ have only three articulations, of which the last two are garnished with long hairs, disposed in two rows, and verticillated on the terminal joint. In the genus Petalocheirus of Palisot de Beauvois,[2] the two anterior legs are singularly expanded into oval plates or shield-like dilatations. These insects are of African origin. The *P. rubiginosus* is blackish-brown, with the antennæ and feet of a rust colour. The thorax is spiny on either side, and surrounded by a line of yellow. The scutellum is surmounted by a straight spine. The only other species with which we are acquainted is the *P. variegatus* of the author last named. In the genus Zelus the form of the body is linear, and the legs very long, slender, and similar to each other. The genus Ploiaria is characterized by the same linear body, and the like length and tenuity of limb; but the two anterior legs have the haunch elongated, and formed, as in Mantis, for the seizure of their prey.

† †

Eyes remarkably large. No apparent neck.

The insects of this subdivision run swiftly along the margin of waters, making occasionally little leaps.

Genus Leptopus, Lat. Rostrum short, arched, and spiny beneath. Antennæ setaceous. Anterior thighs large and spiny.

This genus was established by Latreille upon *L. littoralis*, a small insect about two lines in length, of an obscure ash colour, with some spots upon the elytra, and the margins of these parts whitish. Their membranous appendages are pale, with obscure nervures. The feet are pale yellow. This species was discovered in Spain by Leon Dufour; and another nearly allied to it, *L. lapidicola*, has been taken by Basoches in the department of Calvados.

Genus Acanthia, Lat. Rostrum long, straight, with the labrum projecting beyond the sheath. Antennæ filiform, or slightly enlarged towards the extremity. Form of the body oval.

This genus is composed of insects belonging to the genus *Salda* of Fabricius, such as S. *striata*, *zosteræ*, *littoralis*, &c. We may regard as its type the *Lygæus saltatorius* of Fab., a species which dwells by the banks of rivers, and runs and leaps with agility. Certain species, of which the antennæ are much shorter than usual, and bent over the eyes, the body shorter and more rounded, with the scutellum rather large, form the genus Pelogonus of Latreille. These Hemiptera approach those of the genus *Naucoris* in their nature, and seem to conduct towards them in common with the following.

b.

Four posterior feet slender and long, inserted on the sides of the chest, and distant from each other at their points of articulation. The hooks of the tarsi are very small, indistinct, and placed in a fissure of the lateral ex-

[1] The first joint is often united to the second, and that to the third, by means of a very small article or rotule. (*Règne Animal*, v. 202.)

[2] *Insectes recueill. en Afr. et en Amer.* fasc. i.

tremity of the tarsus. The feet are adapted for rowing or walking on the water. These characters are proper to the genus *Hydrometra* of Fabricius, which Latreille has divided into three, as follows.

Genus Hydrometra,[1] Lat. Antennæ setaceous. Head prolonged into a muzzle, and receiving the rostrum, of which the articulations are by no means obvious, in an inferior groove.

These insects dwell in moist places, and run upon the surface of waters. (Plate CCXLII. fig. 8.) Their bodies are narrow, thin, linear. Their eyes are large and globular, and are placed towards the centre of the lateral parts of the muzzle, or rather muzzle-shaped head. The best known species is *H. stagnorum*, which measures about five lines in length. It is of a black or blackish-brown colour, with the feet of a redder hue. The elytra are very short, with two nervures on each. This species is common throughout Europe. The *H. fossarum* of Fab. is a native of the East Indies. We are inclined to regard it as belonging to the next genus.

Genus Gerris, Lat. Antennæ filiform. Rostrum with three articulations. Anterior feet serving the office of pincers. Second pair distant from the anterior, and as long again as the body. (Plate CCXLII. fig. 9.)

These insects have elongated bodies, are usually of a blackish colour, and are met with on the surface of still waters, on which they advance as it were by starts. Their under surface seems covered by a peculiar coating, of a black or silvery hue, according to the position in which the insect is held, and which probably protects it from the influence of the subjacent liquid. They appear rather to row than to walk upon the surface. The species are insectivorous, and prey upon such of their own class as they can master, and especially upon any land species that have fallen accidentally into the water, and are naturally inactive in that element. These they immediately seize upon with their anterior feet. The *G. lacustris*, Lat. (*Hydrometra lacustris*, Fab.), figured on the plate above referred to, is of a blackish-brown colour, greenish above. The feet are brown. The body is terminated by a projection. This species presents some peculiarities worthy of notice. There are two varieties of it, one of which is winged, the other apterous. The former of these constitute the *punaises aquatiques très-allongées ailées* of Degeer, the latter correspond to the *punaises aquatiques très-allongées non ailées* of that author.[2] Such as make their appearance in spring, and which have without doubt passed the winter beneath the ice, or under cover of the frozen banks, are all apterous, but resemble perfect insects in every other part of their structure. Sexual intercourse takes place among them. It was this latter circumstance which induced Geoffroy to believe that they offered a remarkable exception to a general rule, and that fecundation took place in the state of nymph or larva. Degeer, in combating this opinion, maintained that these apterous insects were of a distinct kind, and perfect in their way. M. Audouin, on the other hand, is of opinion that they may be regarded as individuals of the ordinary kind, proceeding from larvæ of the preceding year, of which the development has been checked by the rigours of the winter season, and the consequent condition of torpidity. He conceives that the wings are not, in these aquatic insects, organs of the first importance, and that the influence of surrounding causes is on that account the more likely to prove effectual, and that thus they remain rudimentary, when the other parts of the body, and the generative system in particular, have attained the maximum of their development. He illustrates this point by reference to the genera *Lampyris* and *Drilus*, in which (in the females) the organs of flight of the perfect insects are scarcely if at all more developed than in the larva state, while all the interior parts of structure are fully and functionally completed. The apterous individuals, then, of *G. lacustris*, which are observed to fulfil the offices of the perfect insect, are larvæ only so far as regards the undeveloped condition of the wings.[3]

General Hardwicke has described a new species of this genus from Nepaul, under the name of *G. laticaudata*. The extremity of the abdomen is remarkable for certain processes like teeth or claws.[4]

Genus Velia. Antennæ filiform, as in Gerris; but the rostrum has only two apparent articulations, the legs are much shorter than in that genus, and are inserted at nearly equal distances from each other.

Like the preceding species, these insects live on the surface of water. Their motion, however, is more like running than swimming. The *V. currens* is blackish-brown, with the superior edges of the abdomen fulvous, spotted with black. The *V. rivulorum* is black spotted with white, the abdomen fulvous.

FAMILY II.—HYDROCORISÆ.[5]

Antennæ inserted and concealed beneath the eyes, shorter than the head, or not exceeding it in length. Tarsi composed of only two articulations. Eyes for the most part remarkably large. These Hemiptera are aquatic and carnivorous. They prick severely with their rostrum, and seize upon other insects with their anterior feet, the joints of which are bent upon themselves, so as to form a kind of pincer. Their heads appear as if sunk into or intimately united to the thorax. The rostrum is short. Their metamorphoses do not differ from those of the other Hemiptera.

Tribe 1st, Nepides.

We here place the species of the unrestricted genus Nepa of Linnæus, commonly called *water scorpions*. They have the anterior legs in the form of hooks or nippers,—composed of a thigh, sometimes large, sometimes elongated, with a groove on its under surface for the reception of the tibia, and of an extremely short tarsus, which forms as it were a hook or crotchet with the tibia. The form of the body in some is oval and much depressed, in others it is more linear. Latreille divides this tribe into the following genera.

Genus Galgulus, Lat. All the tarsi similar to each other, cylindrical, with two distinct articulations, of which the terminal is provided with two hooks. The antennæ do not appear to have more than three articulations, of which the last is the largest, and of an ovoid form.

The only species of this genus with which we are acquainted, *G. oculatus*, Lat. (*Hist. Nat. des Crust. et des Insect.* xii. 286, pl. 95, fig. 9) was placed by Fabricius in the genus *Naucoris*. It is of a dull ashy brown, with some paler spots upon the elytra. The thorax is unequal. The legs are pale brown, with deeper spots. This odd-looking insect was brought by Bosc from Carolina. Its body is short and rough. The head has little length, but is pro-

1 From ὕδωρ, *water*, and μετρεῖν, *measure*.
2 *Mem. sur les Insectes*, iii. 311.
3 *Diction. Class. d'Hist. Nat.* vii. 337.
4 *Linn. Trans.* xiv. 134, pl. 6.
5 From ὕδωρ, *water*, and κορις, *bug*.

longed laterally into two angles which support the eyes. The prothorax is lobed posteriorly, and placed before a triangular scutellum, on each side of which are inserted the short and coriaceous elytra. The thighs of the anterior legs are swollen and dentated beneath, and the tibiæ and tarsi are applied close to them when the insect is in a state of repose. We are not aware that any thing is known of the habits of this insect, further than that it is aquatic.

Genus Naucoris,[1] Geoff. Labrum exposed, large, triangular, and covering the base of the rostrum. Antennæ simple, and consisting of four articulations. Tarsi of the anterior feet terminating in a simple point or crotchet. The middle and hinder pair of legs ciliated,—their tarsi with two articulations, terminated by a pair of hooks.

Of this genus the body is usually depressed, almost ovoid, with the head rounded anteriorly, and the eyes lengthened and depressed. The abdomen is dentated around its edges. The species are extremely active, and swim with great ease and swiftness, making use of their hinder legs as oars. They sometimes quit one pool of water for another, and they then make good use of their wings. They are extremely voracious, and destroy a great number of other insects. The larvæ and nymphs inhabit the same situations as the perfect insects, and differ from them chiefly in the absence of wings. The nymphs indeed exhibit the rudiments of these organs enclosed in a kind of case, from which they expand at the period of the completed metamorphosis. The *N. cimicoides* (*Nepa cimicoides*, Lin.) measures about six lines in length. It is of a greenish-brown, with the head and thorax paler and spotted. The eyes are blackish. The margins of the abdomen are strongly dentated. It is common throughout the fresh waters of Europe.

Genus Belostoma, Lat. Labrum sheathed. Antennæ semi-pectinated. All the tarsi with two articulations. Abdomen terminated by a pair of setæ.

The *B. grandis* (*Nepa grandis*, Fab.) may be regarded as the type of this genus. It is a very large insect, measuring nearly three inches in length. It is of a greyish colour, spotted with brown. The legs are likewise spotted. The thorax is smooth. It is common in collections of foreign insects.

Genus Nepa.[2] Labrum and setæ as in the preceding genus. Rostrum curved beneath. Anterior tarsi with only one articulation,—the middle and posterior pair with two. Antennæ appearing forked. Haunches of the anterior legs short, and the thighs much broader than the other parts.

The body in this genus is almost elliptical, and narrower and more elongated than in the preceding genera. The head is small, and partly lodged in a notch of the thorax. The setæ, which terminate the abdomen, serve, according to some authors, for the purposes of respiration in the moist and muddy places in which they dwell. The Nepæ, in their various states, inhabit the quiet waters of ponds, lakes, and marshes. They swim more leisurely than many of their congeners, and often proceed along the surface of the mud below, in search of the minute insects of which they make their prey, and which they seize with their anterior feet. Their eggs are of an oval form, and, when examined with a microscope, are seen to be crowned by an aigrette of seven small threads. Swammerdam anatomized these insects, and has given us some curious details regarding the arrangement of the eggs in the ovaries. They are so disposed that the crown-like threads of the one which is next the orifice embraces the one which follows, and so on consecutively. The generative system of the male is singular, and very complicated. The larvæ leave the eggs in midsummer. They differ from the perfect insects chiefly in wanting the wings and setæ. The nymphs acquire, as usual, rudimentary wings inclosed in sheaths, and placed on each side of the body. The perfect insect frequently quits its subaqueous abode during the dewy night, and flies about with great agility. The genus is by no means numerous in species, although these seem pretty extensively distributed over the waters of the earth.

The *N. cinerea*, Lin. (Plate CCXLII. fig. 10), is nearly an inch in length, of an ash colour, the upper part of the abdomen red, the tail shorter than the body. We owe to M. Leon Dufour some curious and excellent observations on the anatomy of this species, and on that of *Ranatra linearis*.[3] These insects present a peculiar organ, which the French observer regards as a kind of pectoral trachea, communicating with those of the ordinary kind. It forms in *R. linearis* a pair of elegant *panaches*, or feather-like bunches, of a pearly whiteness, composed of numerous little branches, and situated in the centre of the muscular mass of the breast. In *N. cinerea* the pectoral tracheæ appear to offer the vestiges of a pulmonary organ. They consist of two oblong bodies, placed immediately below the region of the scutellum, clothed by a fine membrane, smooth, and white as satin. They are almost as long as the chest, free except at their extremities, and are filled with a substance like tow, which, when examined under the microscope, presents a homogeneous tissue, formed by vascular arbusculæ. The nervous system appears to consist of two large ganglions, the one placed beneath the œsophagus, the other in the chest betwixt the first and second pair of feet, and throwing out two remarkable cords, divided into two or three threads at their extremities. Only two biliary vessels have been yet observed.

Genus Ranatra, Fab. differs from the preceding chiefly in the linear form of the body, in the rostrum being directed forwards, and in the character of the anterior legs, of which the haunch and thigh are slender and elongated.

These insects do not excel as swimmers. They frequently leave the water in the evening, and are good flyers. They are very voracious. The *R. linearis* occurs throughout Europe. It is pale cinerous, with a yellow tinge; the abdomen reddish beneath. It measures about an inch in length, and the setaceous appendages are as long as the body. The aigrette upon the eggs of this species consists of only two setæ. The genus is by no means numerous in species, but it occurs in the East Indies and America, as well as in Europe.

Tribe 2d, Notonectides.

In this group the two anterior legs are simply curved underneath, with the thighs of the usual size, and the tarsi pointed and thickly ciliated, and resembling those of the posterior legs. Their body is ovoid or nearly cylindrical, and thickish, or less depressed than in the preceding tribe. Their posterior legs are much ciliated, and resemble oars. They are terminated by two small indistinct hooks. They swim or row with great swiftness, and frequently turn upon their backs. They correspond to

[1] From *ναυς*, *boat*, and *κορις*, *bug*.
[2] Supposed by some to have been originally a misprint for *Hepa*, a Latin word applied to the scorpion.
[3] *Annales Gen. des Sciences Physiques*, t. vii.

the genus *Notonecta* of Linnæus, which Latreille divides as follows.

GENUS CORIXA, Geoff. Rostrum very short, triangular, transversely striated. Anterior legs very short, with ciliated compressed tarsi, furnished with a single articulation. The other legs are elongated, and the middle pair are terminated by two very long hooks. Elytra horizontal. Scutellum not apparent. *Sigara* of Fab.

These insects are of an elongated form, the body somewhat flattened, the head large and vertical, the eyes triangular, the prothorax more developed transversely than in a longitudinal direction, but prolonged backwards to a point. They walk defectively, but swim and fly well. We think they never swim upon their backs, like the species of the following genus, but are usually seen as it were suspended by their extremity from the surface of the water, and prepare to dive instantly on the approach of danger. When seized they endeavour to pierce the skin of the captor with their sharp-pointed rostrum; and if they succeed in that effort, pain accompanied by swelling not unfrequently ensues. The genus is not extensive. We may here name, as the most frequent in the fresh waters of Europe, the *C. striata* (*Notonecta striata*, Linn.), which measures about five lines in length, brown, with numerous spots or little rays of a yellowish hue. The head, legs, and under parts of the body, are likewise of the latter colour.

We may here note, that Dr Leach assumes the *Not. minutissima* of Fabricius as the type of his genus *Sigara*. It resembles the preceding genus in many respects, but the body is rather ovoid than linear or cylindrical, and the thorax is provided with a scutellum.[1]

GENUS NOTONECTA,[2] Geoff. Fab. Rostrum articulated and in the form of an elongated cone. All the tarsi with two articulations. The four anterior legs geniculate, with simple cylindrical tarsi. Elytra declined. Scutellum distinct.

The Notonectæ properly so called are characterized by the singular practice of swimming upon their backs, with their bodies somewhat inclined, their heads being elevated during their upward progress, and the contrary while they either rest suspended at the surface or descend towards the bottom of the pool. When these insects are in the act of swimming, they make use only of the middle and posterior pairs of legs, the anterior being applied closely to the chest; but when they walk at the bottom, or over the herbage of aquatic plants, in search of insect prey, they then bring the latter into active service, and merely trail the former after them, or alongside. The females deposit their eggs, which are long and white, on the stalks and foliage of water-plants. The young are produced in spring, and resemble the perfect insects, except in the want of wings. The nymphæ are equally active, and exhibit these organs in a rudimentary state. They are all, of whatever sex, age, or condition, predaceous in their disposition, and, in the absence of more ordinary food, will seize upon and cruelly devour their own species. We are acquainted with about a dozen of the genus, of which about a third inhabit Europe. The others occur in Asia, Africa, and America. The most familiarly known in this country is the *N. glauca* of Linn. (*Nepa notonecta*, Dejeer, *Mem. Insect.* iii. p. 382, No. 5, tab. 18, fig. 16, 17), figured on Plate CCXLII. fig. 11. It is about half an inch in length, of a greenish black beneath, the front of the head of a pale green, the upper and anterior portion of the thorax whitish, the posterior half obscure. The elytra are of a yellowish-grey, with a tint of brown, their sides spotted. The scutellum is black. This insect varies considerably in its external aspect. Those with brown elytra, varied with reddish, may be regarded as *N. maculata* of Lat.

The *N. minutissima* of Linn. must not be confounded with the species so called by Fabricius. The former constitutes the genus *Plea* of Dr Leach, and differs from Notonecta in having the third point of the antennæ larger than the others. The articulations of the anterior tarsi are also of equal length, and the hooks of the posterior legs are large. The form of the body, and texture of the elytra, likewise present some disresemblances.

HOMOPTERA, LAT.

In this second great division of the hemipterous order, the rostrum or sucker originates from the inferior part of the head, close upon the chest, or even from between the two anterior legs. The elytra (almost always inclined) are semimembranous, and of the same consistence throughout. They are sometimes scarcely distinguishable in their texture from the inferior wings. The three component segments of the thorax are united as it were *en masse*, and the first is always shorter than the one following.

The genera of this section are quite dissimilar in their habits to those with which we have been previously engaged. They feed on the juices of plants. Many of the females are provided with a scaly sheath or ovipositor (called *oviscapte* by M. Marcel de Serres). This is usually composed of three dentated blades, lodged in a bivalvular groove. They use it as a kind of saw, with which to produce notches or other excavations in various plants, for the purpose of depositing their eggs in safety.

FAMILY I.—CICADARIÆ.

The genera composing this family present three articulations in the tarsi,—the antennæ are usually very small, conical or awl-shaped, and consist of from three to six portions, including the attenuated seta by which they are terminated. We owe to MM. Ramdhor, Marcel de Serres, Leon Dufour, and Straus, many excellent observations on the internal structure of these insects. According to Dufour, the stomach, or chylific ventricle, is of remarkable length. It commences by an oblong dilatation, either curved or straight, and decreases into an intestiniform canal, which returns upon itself, and opens near the origin of the ventricle, alongside the insertion of the hepatic vessels, and not far from the origin of the intestine. They are all provided with four biliary vessels. In the Cicadæ the ventricle has what Dufour calls "la forme d'une anse," the right portion being dilated into a large lateral, and frequently plaited pouch. Its superior extremity is united to the œsophagus by an upper ligament, and the other leads to the narrow, tubular, very long, reflexed prolongation, with the form of an intestine, which, after its circumvolutions, re-ascends to unite with the pouch near the insertion of the hepatic vessels. This truly singular disposition of the chylific ventricle, which, after several convolutions, finally disgorges into itself, by the completion of a circle traversed throughout by the alimentary fluid, is doubtless a circumstance not easily explained in a physiological point of view. It is, however,

[1] *On the Classification of the natural tribe of Insects Notonectides, with Descriptions of the British Species*, Linn. Trans. xii. p. 10.

[2] From νωτος, *back*, and νηκτης, *swimmer*.

[3] From ὁμὸς, *equal*, or *the same*, and πτερα, *wings*,—in reference to the similar texture of the organs of flight.

not the less a well determined fact, and one which constitutes the most characteristic feature in the anatomy of the Cicadæ and other Cicadariæ.[1] In the *Ledra aurita* of Fabricius, the inflated portion of the chylific ventricle is placed immediately after the crop; and there is but a single cluster of salivary sacks on each side, a character likewise observable in *Cercopis spumaria*, or Frog-spittle; while in Cicada there are two on each side. In *Membracis cornuta* the *anse duodenal* of Dufour is replaced by a short pouch, likewise attached to the œsophagus by a suspensory filament, a character peculiar to these insects.

1st, Stridulantes.

Antennæ composed of six articulations. Three simple eyes. This division includes the *Manniferæ* of Linnæus (Tettigonia, Fab.), and forms the

Genus Cicada of Oliv. and Lat. Head transversal. Eyes large. Prothorax broad or transversal, with a straight posterior margin; the mesothorax large, with the form of an X on its posterior edge. Elytra generally vitreous. A large scaly operculum covers a cavity on each side of the base of the abdomen in the males.

These insects differ from those that follow, not only in the structure of the antennæ and the amount of the simple or stemmatic eyes, but also in their being all destitute of the faculty of leaping. The males are musical, that is, during the heat of summer, they produce, by a peculiar structure, a loud and continuous cry or stridulation, called by courtesy a song. When we examine the lateral base of the abdomen of a male Cicada, we perceive two large scaly plates of a rounded figure, approaching that of a demi-oval cut through its smaller axis; so that each plate presents a side which is rectilinear, while the remaining portion exhibits a rounded outline. It is by the straight side that each plate is fixed without articulation, on the metathorax, of which it forms a portion. When we lift up these plates we discover a cavity on each side of the abdomen, divided into two principal chambers by a horny triangular septum. When viewed from the side of the abdomen, each cell presents anteriorly a white and plaited membrane; and lower down there is another membrane, thin, light, and transparent as glass, called *le miroir* by Réaumur. Some authors have regarded this as a kind of drum or tambour, and the seat of sound; but that organ has yet to be described. If we open the mirror from above, we perceive on each side of it another plaited membrane, moved by a very powerful muscle, composed of a great number of straight parallel fibres, and arising from the horny septum. This latter membrane is the tymbal or drum, on which the muscles act by contraction and relaxation, alternately tightening and restoring it to its original state. This is the true origin of the sound, which in fact may be produced even after the death of the insect, by jerking the muscle.[2] We may add, that M. Chabrier has perceived a stigmatic opening, not noticed by Réaumur, at the inferior junction of the mesothorax and metathorax; while Latreille has discovered on the posterior part of each tymbal a distinct hole, which, he thinks, serves for the egress of the air. Chabrier, however, is of opinion that the air makes its escape through the two stigmata placed at the base of the opercula before mentioned.[3] Further investigation will probably show that the analogues of this singular structure exist in other insects. Indeed, the principal pieces have been already recognised, though much more feebly developed, not only in the female Cicadæ, but also in certain species of the orthopterous genera *Acrydium* and *Truxalis*. In the opinion of Audouin, the plates or shutters (*volets*) are merely large prolongations of the *epimera* of the metathorax.[4]

The Cicadæ dwell on shrubs and trees, of which they suck the juices. The females, which are provided with ovipositors, lay their eggs in holes, which they form in the small branches or twigs of trees. The parts thus attacked are easily recognised by little irregularities, formed by a portion of the wood which has been raised. These elevations are placed in a row, one after the other, upon the same side of the branch. The different holes have a diameter nearly equal. Their depth is from three to four lines. They commence in an oblique direction; but as soon as they reach the pith, they become nearly parallel with the twig itself. The ovipositor does not pierce beyond the pith; and the number of eggs placed in each hole varies from four to ten. They are white, oblong, and pointed at both ends. The larvæ are white, and furnished with six feet. They soon quit their sylvan nurseries, and make their way under ground, where they gnaw the roots of plants. Their anterior legs are short, with strong dentated thighs, and are well adapted for digging. They increase rapidly in size, and are ere long transformed into nymphs. These are of a dingy-white colour, and are chiefly remarkable for their very short and inflated fore legs, which are dentated, and serve them to penetrate the earth. After living for about a year in this state, they leave the ground during the prevalence of warm weather, and, climbing up the stems of trees, their skin first hardens, and then bursts all along the centre of the dorsal line. The perfect insect then escapes from its exuviæ. It is at first very soft, and of a greenish colour; but it soon attains a firmer consistence, and various external markings make their appearance, according to the characteristic aspect of the different kinds.

These insects were well known to ancient writers, and their so-called song has been celebrated by poets from the highest antiquity. To ourselves it appeared monotonous and fatiguing, although heard not seldom among the leafy groves which shadow the fair white walls of the "Etrurian Athens." The Cicada is the insect so frequently and fondly commemorated by the Greek poets under the name of τεττιξ,—which our translators have generally though erroneously construed *grasshopper*. Linnæus, with his accustomed propriety, applied the term *Gryllus* to the locust and grasshopper tribes, and that of Cicada to the "beloved of the Athenians." The name of tree grasshopper, however, which is sometimes used, applies with sufficient accuracy to the latter, and indicates one of its characteristic habits, that of usually perching upon trees. The true grasshoppers are ground insects. The Cicadæ are scarcely known in Britain, although the species attached to ash-trees (*C. orni*) is recorded as an English insect, in common with *C. hæmatodes*. They abound in Italy and other southern parts of Europe. The Italians call them *Cicale* and the French *Cigales*, both words being no doubt derived from the Latin. They are frequently mentioned by the modern Italian poets; and Lord Byron somewhere alludes to the "shrill Cigala, people of the pines," thus recognising their *arboreous* disposition. Although held in the highest estimation as *children of the soil* by the Athenians, who used to wear golden images of them in their hair, there is no doubt that they were also regarded by the Greek nations under a less intellectual aspect. Aristotle mentions that they were used as food, and that they were particularly esteemed just before

[1] *Règne Animal*, v. 211. See also *Recherches Anatomiques sur les Cigales*, in the 5th vol. of the *Ann. des Sciences Nat.*
[2] *Règne Animal*, v. 214.
[3] *Essai sur le Vol des Insectes.*
[4] *Dict. Class. d'Hist. Nat.* iv. 125.

Hemiptera Homoptera.

the conclusion of the nympha state. The insect which he mentions under the name of *Tettigometra*, or mother of the Cicadæ, is in fact merely that intermediate condition of nymph, prior to the development of the organs of flight. In that state, as well as when under the form of larva, it lives upon the ground, or even beneath it, feeding on herbage and the roots of plants; but when about to undergo its final metamorphosis, it climbs a tree, its outer garment bursts asunder and is thrown off as exuviæ, the wings expand their folds " voluminous and vast," and we have then the perfect insect or tree grasshopper, the Cicada of the Latins, and Tettix of the Greeks, so beautifully addressed by Anacreon:—

We deem thee blest, thou grasshopper, as on the highest trees,
Having sipp'd a little dew, thou sitt'st, like a monarch, at thine ease;
For every thing before thee, whate'er the fields produce,
And the fruits of every season, are intended for thy use.
Thou art the friend of husbandmen, since harmless are thy ways;
By mortals held in reverence, sweet seer of summer days.
The muses love thee dearly, to Phœbus art thou dear,
Who with that voice hath gifted thee, so musical and clear.
Song-skilled, earth-born, song-loving one, old age to thee's no load;
Fleshless, bloodless, passionless, thou almost art a god.

A great variety of opinion seems to prevail regarding the musical accomplishments of these celebrated insects. Virgil accused the Italian Cicadæ of bursting the very shrubs with their noise—" Et cantu querulæ rumpent arbusta Cicadæ;" and Dr Shaw in his Travels calls it, alluding to its shrilly cry, " the most troublesome and impertinent of insects." Kirby and Spence tell us that in some countries it is execrated for its deafening din. Yet some one who desired to compliment Plato, asserted that his voice was as sweet as a grasshopper's; and we may all remember the story of the rival musicians (Eunomus and Ariston), one of whom gained the victory in consequence of a Cicada settling on his harp, and supplying the place of a broken string. Even at this day the song of the *Tettigonia Tibicen* of Surinam is supposed so greatly to resemble the sound of a musical instrument, that the insect itself is called the *Harper*. The following is Mr Elton's translation of Meleager's invocation.

O shrill-voiced insect! that with dew drops sweet,
Inebriate, dost in desert woodlands sing;
Perched in the spray-top with indented feet,
Thy dusky body's echoings harp-like ring:
Come, dear Cicada! chirp to all the grove,
The Nymphs and Pan, a new responsive strain;
That I, in noonday sleep, may steal from love,
Reclined beneath the dark o'erspreading plane.

We shall here conclude our general sketch of these insects by observing that the substance used in medicine, and known by the name of *manna*, is an exudation from certain species of ash (*Fraxinus rotundifolia et ornus*) which flourish in the south of Europe. It has been observed to be frequently produced by the puncturing of the Cicadæ, which feed on the juices of those saccharine trees. The largest insect of the genus in Europe is *C. plebeia* of Linn. Its cry is very strong and shrill; and as it is well known in Italy, there can be no doubt of its being the species mentioned by Virgil. If identical with the Athenian Cicada, its voice does certainly by no means correspond in musical intonation to what might be inferred from its recorded character as a lyrist among the ancient Greeks. The pleasure produced may however depend upon association; for, as Cowper says,

Sounds inharmonious in themselves, and harsh,
Yet heard in scenes where peace for ever reigns,
And only there, please highly for their sake.

It is said that the males alone are musical, which may perhaps be one reason for their continued cheerfulness; for, as the Rhodian Xenarchus has it,

Happy the Cicadas' lives,
Since they all have voiceless wives.

The amount of species in the genus Cicada is considerable. They are spread over almost all the regions of the earth, especially in the warmer latitudes.[1] The greater number are foreign to Europe. Our bounds will not admit of more than a brief notice of a very limited number of species. The *Cicada Orni* is a European insect, common in France and Italy. It is about an inch long, yellowish, paler beneath, but mixed with black on the upper portions. The margins of the abdominal segments are reddish. There are two rows of blackish spots on the upper wings, those next the inner margin being the smallest. Its voice is hoarse, and does not extend so far as that of several other species. This is the kind which, by wounding the tree from which it derives its specific name (a species of wild ash), causes a peculiar and honey-like fluid to flow from it. It afterwards dries and hardens, and in that state is used medicinally under the name of manna. The *C. plebeia*, Lin. (*Tettigonia fraxini*, Fab.), figured on Plate CCXLII. fig. 13, is the largest species found in France. It is black, with some spots on the first segment of the thorax, its posterior margin, the raised and arched portions of the scutellum, and several veins on the elytra, reddish. Its cry is strong and shrill. The *C. hæmatodes* is black, with the front of the thorax and legs spotted. The edges of the abdominal segments, and the reticulations of the elytra, are red. This species occurs in the south of France, but is rare in the vicinity of Paris. Its voice is weaker than that of the preceding species. Olivier has described sixty-six species in all.[2] We are indebted to Stoll for a monograph of the Cicadæ, already referred to in a subjoined note.

2d, Mutæ.

Antennæ with only three distinct articulations. Two ocelli or simple eyes. Legs, in general, adapted for leaping. Neither sex provided with organs of sound. The elytra are frequently coriaceous and opake, and the females of many species are observed to envelope their eggs in a white and cottony substance.

A. *Fulgorellæ.*

Antennæ inserted immediately beneath the eyes, and the front frequently prolonged into a muzzle, of variable figure according to the species.

Genus Fulgora.[3] Front of the head prolonged or expanded into a muzzle. No appendages beneath the antennæ. Thorax of two apparent segments,—the posterior margin of the first straight, of the second triangular.

These insects are remarkable for the varied and beautiful markings of their elytra and wings, and for the singular form of their expanded muzzles, from which a luminous or phosphoric emanation proceeds during the night. Hence several of the species are known (in common with *Elater*, *Lampyris*, and other coleopterous kinds) under the name of fire-flies. The greater number of the species are exotic, and inhabit the sultry regions of Cayenne, Guadaloupe, Senegal, the East Indies, and China. They

[1] *Encyclopédie Méthodique*, t. v. p. 742. See also Stoll's *Représentations exactement coloriée d'après nature des Cigales et des Punaises.*
[2] In *Encyclop. Méthod.* v. 742. See also Latreille's *Gener. Crust. et Insect.* iii. 154; and the *Syst. Rhyng.* of Fabricius, genus *Tettigonia.*
[3] From *fulgor*, splendour.

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dwell on trees, but their special manners are but slightly known. We shall here indicate a few of the more noted species.

F. laternaria, Linn. is a large and remarkable insect from South America, drawn and described in most illustrated works on entomology. Its muzzle is nearly straight as to its direction from the head, but it is vesicular and inflated, or swollen out and rounded, at the sides and extremity. The ends of the under wings are pleasantly varied with black and yellow, in the form of an expanded spot, resembling the eye of a peacock's feather. Madame Merian informs us, that from the head or front of this species a light is seen to shine during the darker hours, so clear and brilliant that it is easy to read by its rays. She adds, that during the day it is transparent as a bladder, and radiated with red and green. The indefatigable and accurate Réaumur, desirous to ascertain by anatomical investigation the proximate cause of this curious phenomenon, opened one of these vesicular expansions, but he found it empty, except of air, and containing no organic structure. We must bear in mind, however, that the individual examined was in a state of desiccation. The species is common at Guadaloupe and Cayenne, where it is known by the name of fire-fly. It flies well, and hovers habitually about the summits of the tallest trees. Its luminous faculty has been sometimes called in question, especially by M. Richard, who captured many at Cayenne, but never saw them shine. Yet the testimony of Madame Merian, and the general application to the species of the name of *mouche à feu*, notwithstanding the fruitless results of Réaumur's examination, suffices to establish that fact. It is probable, however, that the phosphoric emanation from this and other species is only perceptible at certain seasons of the year, and this consideration may explain the discrepancy arising from M. Richard's observations. *F. candelaria*, Fab. (Plate CCXLII. fig. 12), is a native of China and other eastern countries, and is very abundant in collections. It is known among us by the name of *Lantern fly*, and may be easily recognised by its long cylindrical snout, arched in an upward direction, its greenish reticulated elytra, and orange-yellow wings with black extremities. At night this insect has been said by some to glitter among the dark recesses of the Banyan tree, which

> ....to Indians known,
> In Malabar or Deccan spreads her arms,
> Branching so broad and long, that in the ground
> The bended twigs take root, and daughters grow
> About the mother-tree, a pillar'd shade
> High overarch'd, and echoing walks between.

And they are likewise observed to dance in perpetual motion around the outmost branches of the spreading tamarind, producing a brilliant and singularly beautiful effect.[1] *F. Europæa*, Lat. (Stoll, *Cigales*, pl. xi. fig. 51), occurs in the south of France, Italy, and the islands of the Mediterranean. Its front assumes the form of a conical advancement, with three raised lines above and five below. The elytra and wings are transparent, with green reticulations. There are three raised lines on the thorax.[2]

Genus Otiocerus, Kirby. Muzzle advanced. Simple eyes wanting. Two small appendages beneath each antenna.

Genus Lystra, Fab. Head transverse, and without any prolongation in the form of muzzle. Two simple eyes. Second articulation of the antennæ granular, and almost round.

The species of this genus at first sight resemble small *Cicadæ*. The extremity of the body, in the females, is furnished with little bundles of cotton threads, beautifully white, with which, it is presumed, they surround their eggs. We are acquainted with many species from China, the East Indies, and South America. We shall here mention only *L. lanata*, Fab. (*Cicada lanata*, Lin.), of which the sides of the front are red, and the extremities of the elytra black, with points of blue. We receive it from Cayenne and the Antilles.

We shall here indicate a few genera, into the detailed history of which we cannot enter. The Cyxii of Latreille resemble Lystræ, but the second joint of the antennæ is smooth and cylindrical. Under the appellation of Tettigometra, Latreille has separated certain insects analogous to the preceding, but with the antennæ lodged between the posterior and lateral angles of the head, and those of the anterior extremity of the thorax. The eyes are not projecting.[3] The preceding genera are provided with simple eyes; but in such as follow, these organs are wanting.

The species with large elytra, and the prothorax shorter in the middle than the mesothorax, compose the genus Pœciloptera of Latreille and Germar (*Flata* of Fabricius).[4] In Issus, Fab. the prothorax is as long at least as the mesothorax; and the elytra, scarcely longer, or sometimes shorter, than the abdomen, are dilated at their base, and then narrowed.[5] Sometimes the antennæ are at least as long as the head, and are most frequently inserted in an inferior emargination of the eyes. The genus Anotia of Kirby resembles Issus in the insertion of the antennæ.[6] In Asiraca of Lat. (*Delphax* of Fab.), the antennæ are inserted in an inferior emargination of the eyes, and are as long as the head and thorax united. Their first joint is usually longer than the second, and is compressed and angular. In Delphax, as constituted by Latreille, the antennæ are similar in their insertion, but they are never much longer than the head, and their first joint is much shorter than the following one, and without ridges. The simple eyes are apparent. The genus Dérbe of Fab. is allied to Anotia. The species are little known. They are all exotic, and most of them come from South America.

B. *Cicadellæ.*

Antennæ inserted between the eyes. Latreille subdivides this portion of the family of Cicadariæ into the following genera.

He commences with the species which, with the exception of a few (the Ledræ), formerly composed the genus *Membracis* of Fabricius. The head is much inclined or lowered anteriorly, and prolonged to an obtuse point, or under the form of a clypeus, more or less semicircular. The antennæ are always very small, terminated by an inarticulate seta, and inserted into a cavity beneath the margin of the head. The prothorax is sometimes dilated and horned on either side, prolonged and restricted posteriorly to a point or spine, either simple or compound, sometimes elevated longitudinally along the back, compressed into a sharp edge or crest, and sometimes projecting and pointed forwards. The legs are scarcely spiny.

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[1] It is now much doubted whether any insect of the hemipterous order is actually luminous.

[2] For the other species of this genus see the works of Stoll and Fabricius, last cited, and the *Encyclop. Méthod.* article *Fulgore.*

[3] Germar, *Magazin der Entomologie*, iv. 7.

[4] *Gener. Crust. et Insect.* iii. 165; *Mag. der Ent.* iii. 219, iv. 103-4.

[5] *Systema Rhyngotorum*, p. 199.

[6] *Linn. Trans.* xiii. pl. i. figs. 9, 10, 11, 15.

a.

No apparent or exposed scutellum properly so called.

*

Tibiæ, especially the anterior, strongly compressed and foliaceous. Upper part of the head always forming a kind of semicircular clypeus.

Genus Membracis, Fab. Prothorax elevated, compressed, and foliaceous along the middle of the back.

Of this pretty numerous genus we shall notice only *M. foliata*, Fab. (Plate CCXLII. fig. 14), which is of a blackish brown, the front advanced, flattened, the thorax marked by an arch and band of white. The latter part is greatly elevated, flattened laterally, forming a salient crest, advancing over the head, which it almost entirely covers, and terminated posteriorly by a point prolonged beyond the abdomen. The elytra are oval, longer than the wings. The legs are elongated, flattened, rather broad. The anterior tibiæ are shorter, of an oval form, and flattened. The native country is Cayenne.

Genus Tragopa, Lat. Prothorax presenting on each side a horn or salient point, without any intermediate elevation, and prolonging itself posteriorly into an arched projection of the length of the abdomen, and occupying the place of the scutellum.

This genus is composed of certain species from Brazil, which M. Latreille regards as analogous to *M. glabra*, *albimacula*, and *xanthocephala* of Germar.

* *

Tibiæ of the ordinary form, not foliaceous.

Genus Darnis, Fab. Posterior prolongation of the prothorax covering almost the whole, or the greater portion, of the upper part of the abdomen and elytra, and forming an elongated and arched triangle.[1]

Genus Bocydium, Lat. Elytra entirely or in greater part exposed, the posterior and scutellar prolongation of the prothorax being narrow, and more or less lanceolate or spiniform.

The *Centrotus horridus*, *trifidus*, *globularis*, *clavatus*, and *claviger*, of Fabricius, belong to this genus.

b.

Scutellum partially exposed, even although the prothorax is prolonged;—the posterior extremity of the latter offering a transverse suture, which distinguishes it from the scutellum.

Genus Centrotus,[2] Fab. Similar to *Membracis*, but the thorax is dilated horizontally, and covers only a part of the body.

C. *cornutus*, Fab. (*Cicada cornuta*, Linn. Plate CCXLII. fig. 15), is of a blackish-brown, the thorax with a horn on each side, and prolonged posteriorly to a sinuated point of the length of the abdomen. This species measures about four lines in length. It occurs in France, and other parts of Europe, in woods, on ferns, &c. and is known by the name of *petit diable*. *C. genistæ*, Fab. is of an obscure brown, the thorax without horns, but terminated posteriorly by a straight sharp point, as long as the half of the abdomen. It is only half the size of the preceding, and occurs on the broom. It is called *demi-diable* by the French.

M. Latreille now proceeds to those species of which the head, if not upon a level with, is scarcely lower than, the prothorax, and is horizontal or slightly inclined when seen from above. The prothorax is neither elevated in the centre, nor posteriorly prolonged, and offers at most some lateral dilatations. The mesothorax presents itself under the form of an ordinary-sized triangular scutellum. The elytra are always entirely exposed, and the posterior tibiæ at least are spinous.

In several genera the thorax bears the form of an irregular hexagon, prolonged and narrowed posteriorly, and terminated by a truncation, serving as a support to the base of the scutellum, which it frequently receives into itself,—the truncated portion being concave or emarginate. In the genus Ledra, Fab. the vertex is triangular, and bears the ocelli. The antennæ are inserted upon or above an ideal line drawn from one eye to another. The head is very flat before the eyes, in the form of a transverse clypeus, arcuated and terminated in the centre of its anterior margin by an obtuse angle. All the under parts of the head are plane, or on the same level. The sides of the prothorax are raised in the form of rounded horns. The posterior tibiæ are much compressed, and as if margined exteriorly by a dentated membrane. The *Cicada aurita* of Linn., or *grand diable* as it is called by Geoffroy, belongs to this genus. In the genus Cercopis, Fab. the third joint of the antennæ is conical, and terminated by an inarticulate seta. Of this genus *C. sanguinolenta* is a well-known and ornamental British species, as is also *C. spumaria*, Linn. of which the larva inhabits a white foam frequent on the leaves and stalks of various plants, and called *frog-spittle* in England—*gowk-spittle* in our northern parts of the kingdom. The latter species is by some classed in the genus *Tettigonia*.

In other genera of Cicadariæ, which terminate our present family, the prothorax is scarcely if at all prolonged posteriorly, and terminates, at the height of the origin of the elytra, by a nearly straight line, the length of which is nearly equal to the breadth of the body. The scutellum, measured at the base, occupies a great proportion of that breadth. Here are ranged the genera Eulopa, Eupelix, Penthimia, Jassus, and Tettigonia properly so called.[3]

FAMILY II.—APHIDII.

These singular insects are distinguished from those of the preceding family by the tarsi, which have only two articulations, and by the antennæ, filiform or setaceous, longer than the head, and composed of from six to eleven articulations. Such as possess organs of flight have always two elytra and a pair of wings. The species are usually very small,—their bodies generally of a soft consistence, the elytra and wings nearly alike, or differing merely in size and thickness. They lay a prodigious number of eggs, and their mode of production is in other respects very remarkable.

In some the antennæ consist of from ten to eleven articulations, of which the last is terminated by a couple of setæ. These are leaping insects, and compose the genus Psylla of Geoffroy (*Chermes*, Linn.). They are known under the title of *faux-pucerons* to the French naturalists, as distinguished from the true Aphides after mentioned. They live on trees and various plants, by the juices of which they are nourished. Both sexes are winged. The body of the larvæ is usually very flat, the head large, the abdomen rounded posteriorly. Their feet are terminated by a small membranous vesicle, furnished beneath with a couple of hooks. The nymphs are distinguishable by four broad flat dorsal portions, which constitute the sheaths of the incipient wings and elytra. Several species are covered during both of those immature conditions

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[1] For the species, see the *Systema Rhyngotorum* of Fabricius.

[2] From κεντρον, *spine*, and ωτος, *ear*.

[3] See the fourth volume of Germar's *Magazin der Entomologie*, and the *Règne Animal*, t. v. p. 222–3.

by a white and cottony substance, disposed in flakes. Their fæces form threads or masses of a gummy and saccharine nature. Several species, by the wounds which they occasion to plants while sucking their juices, occasion the growth of peculiar excrescences on the buds and leaves, resembling gallnuts. Of these is *Psylla buxi* (*Ch. buxi*, Linn.), which is green with yellowish-brown wings. Mr Stephens has named a great many British species as belonging to this genus.[1] Latreille has founded the genus Livia upon a species which dwells among rushes (Plate CCXLII. fig. 17). The antennæ are much thicker near the base than towards the extremity.

In other Aphidii the antennæ have only from six to eight articulations, of which the last is not terminated by a couple of setæ.

Some have the elytra and wings linear, fringed with hairs, and placed horizontally upon the body, which is of an almost cylindrical form. The rostrum is very small or indistinct. The tarsi are terminated by a vesicular article, unfurnished with hooks. The antennæ consist of eight granular articulations. Such are the species which form the genus Thrips of Linn. (Plate CCXLII. fig. 18). These insects are very small, extremely active, and seem to leap rather than fly. When teazed, they raise and recurve the extremity of the abdomen, after the manner of the Staphylinidæ. They live among flowers and other parts of plants, and beneath the bark of trees. We may add, that although Latreille did not perceive in the organization of the mouth of these insects any characters essentially different from such as distinguish that organ among the other component parts of the homopterous Hemiptera,—yet M. Straus, who has studied the subject very laboriously, and with his wonted intelligence, is of opinion that the genus Thrips belongs in fact to the orthopterous order.

Others have the elytra and wings oval or triangular, without fringe, and inclined or tectiform. The rostrum is distinct. The tarsi are terminated by two hooks. The antennæ consist of from six to seven articulations. Such are the species which compose the great genus *Aphis* of Linn. which is now divisible as follows.

In the genus Aphis properly so called, the antennæ are longer than the thorax, of seven articulations, of which the third is elongated. The eyes are entire, and the abdomen is furnished with two horn-like projections at its posterior extremity. The species dwell together in society on various trees and plants, of which they suck the juices. They walk very leisurely, and cannot leap. The two horn-like processes just mentioned are hollow tubes, from which a drop of transparent liquid frequently exudes. It partakes of the property of sugar, and is much sought after by ants, who suck it with avidity from the living Aphides. This curious fact was first noticed by M. Boissier de Sauvages, and has since been amply confirmed by M. P. Huber. The desired liquor seems to be given out voluntarily by the aphis, when solicited so to do by a gentle tap from the ant's antennæ. A single aphis may be sometimes seen surrounded by three or four ants, all in the act of deriving from it a plentiful and nectareous meal.[2] The congregations of the Aphides consist, in spring and summer, of apterous individuals, and of nymphæ with undeveloped wings. All of these are females, which give birth to *living young, et sans accouplement préalable.* The males, which consist both of winged and apterous insects, are produced towards the end of summer, or during the autumnal season. They fecundate the last broods produced by the females first mentioned; which broods consist of apterous females, differing from their progenitors in requiring impregnation prior to the continuance of their kind. They lay *eggs* soon after the sexual intercourse, and these remain in the crevices of trees, &c. throughout the winter, and in spring produce the broods above alluded to, which are capable of producing living young, without assistance from each other. " L'influence d'une première fécondation s'étend ainsi sur plusieurs générations successives. Bonnet, auquel on doit le plus de faits sur cet objet, a obtenu, par l'isolement des femelles, jusqu'à neuf générations dans l'espace de trois mois."[3] M. Duvau has recently added some observations to those of Bonnet and Réaumur on this singular subject.[4] By this extraordinary process of production, vast multitudes are brought forth during a favourable season, and the injury to vegetation, by the absorption of the juices, and the obstruction of the natural pores, is consequently great. Réaumur calculates, that in the course of five generations, a single mother may be the means of producing 5,904,900,000! But fortunately they are liable to the attacks of numerous enemies, and are greedily devoured by many other insects. The larvæ of the genus *Hemerobius*, those of different dipterous species, and of the *Coccinellæ* or lady-birds, make the helpless Aphides their constant prey. We cannot here describe the species, but shall content ourselves by naming a few familiar examples. *Aphis rosæ* (Plate CCXLII. figs. 19 and 20) is a small green species, very abundant on the younger shoots of roses, the flowering of which it seems to damage or destroy. Its hordes may be killed by dipping the affected branch into soapy water. *A. quercus* occurs on the oak, and is remarkable for the great length of its beak, which is at least three times as long as the body. It is of a brown colour. *A. fagi* is attached to the beech tree, and covers itself, as do many other species, with a white and cotton-like down, which exudes from its body. Including the genus *Eriosoma* of Leach, we have above fifty species of aphis in Britain. In the genus Aleyrodes,[5] Lat. (*Tinea*, Linn.), the antennæ are short, composed of six articulations, and the eyes are emarginate. *A. Chelidonii* of Lat. (*T. proletella*, Linn.) is found upon the celandine (*Chelidonium majus*), and other plants. It resembles a little moth. The larva is oval, flat, and shaped like a small scale. The nymph is fixed and enclosed in an envelope, so that its transformations differ from those of its congeners. Indeed the somewhat anomalous character of this insect has been the cause of its being described under a great variety of names.[6] Mr Stephens enumerates five British species, including the one just mentioned.[7]

FAMILY III.—GALLINSECTA.

The insects of this family seem to have only one articulation to the tarsi, and are generally so described. It

[1] *Systematic Catalogue*, part ii. p. 361.

[2] The viscous drops so frequent on the foliage of many trees, and commonly known by the name of *honey-dew*, is this secretion from the Aphides. We have seen it falling from a willow tree like a gentle and continuous shower, and ascertained its origin by discovering at the same time millions of these insects incrusting the upper branches, and each giving out from time to time a minute drop of nectareous fluid.

[3] *Règne Animal*, t. v. p. 227.

[4] *Ann. des Sciences Nat.* t. v. p. 224.

[5] From αλευρος, *flour*, in allusion to the farinaceous powder by which these insects are often covered.

[6] See Geoffroy, *Hist. des Insect.* t. ii. p. 172; Réaumur, *Mem.* 7th, t. ii.; and *Dict. Class. Hist. Nat.* t. i. p. 211.

[7] *Systematic Catalogue*, part ii. p. 367.

Hemiptera Homoptera.

is the opinion, however, of M. Dalman, that those parts consist of three joints, with a single hook at the extremity.[1] The males want the rostrum, and have only two wings laid horizontally on the body; their abdomen is terminated by a pair of setæ. The females are winged and provided with a rostrum. The antennæ are filiform or setaceous, and consist, for the most part, of eleven articulations. There are only nine in the males of the species described by M. Dalman. These creatures form the noted genus *Coccus* of Linn. commonly called cochineal insects. They are also known by the name of *Chermes*,[2] and their history and attributes are sufficiently remarkable.

We may frequently perceive on the branches of various trees multitudes of small oval or rounded bodies resembling scales, adhering closely to the wood, and presenting no indications of any external organs. These are insects of the genus Coccus, the *progallinsectes* of Réaumur. Their history was for a long period extremely obscure, and the species employed in commerce was even at one time regarded as a kind of grain. It was only towards the termination of the seventeenth century that M. Plumier clearly established their insect origin. We are indebted to Réaumur for a complete history of the life and transformations of the European kinds. The larvæ of both males and females, on first quitting the egg, are tolerably active, and run about among the leaves and branches. They are, however, so extremely small at that period, as not to be distinctly discernible without the aid of a microscope. They are flat, ovular, apterous, with short and indistinctly articulated antennæ. The males have no apparent organs of manducation, although the females are furnished with a small, extremely short, almost conical beak, inserted between the first and second pair of feet, nearly perpendicular in its direction, and composed of a four-jointed sheath containing a sucker of three pieces. It is with this instrument that they pump the juices of the leaves and tender stems. They also fix themselves from time to time for the purpose of changing their skin, and after arriving at a certain size, they become definitely fixed in some chosen spot, usually at the bifurcation of a branch, where they form a little nest, protected by a tapestry of cotton. They then attain the perfect state, and are apterous (we speak of the females) even in that otherwise complete condition. Their head is semicircular, their mouth is still formed of the beak which existed in the larva state, and the eyes are small. The thorax is not easily distinguished from the abdomen, the segments of which are distinct. When the insect has attained its full growth, its abdomen is found filled with a multitude of minute eggs. The larvæ of the males, though by no means rare, are much less numerous than those of the other sex. Their mode of sustenance, owing to the want of the sucker, is not distinctly known; but they increase in size, and after a time their skin hardens, and serves as a cocoon, in which they undergo their transformation to the nympha state. In the latter condition they are remarkable for the anterior pair of legs being directed forwards. Towards the beginning of spring these cocoons open at their posterior portion, and the perfect male insect comes forth stern foremost. It is of a more elongated form, with a round head furnished with two small eyes and a pair of rather long antennæ. The thorax is rounded, and has attached to it a pair of long wings, folded horizontally one over the other, and very delicately veined. (For a male Coccus see Plate CCXLII. fig. 16; the female is shown by figures 21 and 22). The male is less than the female, and more active, although it uses its wings very sparingly. As soon as it attains the perfect state, it sets off in search of the other sex, which still remains fixed in the nest, as formerly mentioned. The oviposition of the female is another remarkable peculiarity in the history of these insects. Though excluded from the body, the eggs do not appear externally, but are made to pass beneath the abdomen, and between it and the cotton tapestry above alluded to. In proportion as the insect becomes empty, the lower surface of the abdomen approaches the upper one, so as to leave beneath the body a kind of arch or cavity for the reception of the eggs. The perfect female never stirs a step in the course of her life, but having laid her eggs she dies, and her body shrivels up and hardens, and thus forms a cocoon or covering for the incipient young. These, as soon as hatched, work their way from beneath the dead body of their parent, making their escape by its posterior extremity.

These curious insects are certainly hurtful to vegetation, by causing a too abundant transudation of their juices; and they consequently excite the jealousy of those who cultivate the finer trees, such as the peach, the orange, the olive, and the fig. Certain species attack also the roots of plants. But, upon the whole, the advantages which we derive from this genus of insect amply counterbalance whatever injuries it may occasionally inflict upon us. The species are very numerous. We shall here notice only a few of the more remarkable.

Of the kind called Kermes, is that known to naturalists by the name of *Coccus Ilicis*, of which the female attains to the size and form of a pea. It is of a violet-black colour, covered by a whitish powder. This species is common over the south of Europe on the evergreen oak, and appears to be widely distributed over many of the south-eastern countries of the ancient world. It occurs abundantly in Spain, where it attaches itself chiefly to the twigs and leaves of a small species of spiny-leaved oak, frequent in the southern parts of that romantic kingdom, especially on the slopes of the Sierra Morena. Many of the inhabitants of Murcia have no other means of subsistence than those procured by collecting the Kermes. Women are usually so employed, and they scrape the adhesive insects from the trees by means of their nails. Though supplanted over the greater portion of Europe by the introduction of the more famous cochineal (*Coccus cacti*), which is an American species, it is still extensively used in India and the Persian dominions.[3] It has been employed from time immemorial to impart a blood-red or crimson dye to cloth, and was known to the Phœnicians by the name of *Thola*. It was called coccus (Κοκκος) by the Greeks, and kermes or alkermes by the Arabians. According to Beckman, the epithet *vermiculatum* was applied to it during the middle ages, when its insect origin came to be generally understood, and hence is derived our English word vermilion. The French term *cramoisi* is evidently from the Arabic. It is supposed to have been by means of this substance that the curtains of the tabernacle (Exodus, xxvi. &c.) were dyed of a deep red (which the word scarlet then implied, rather than the colour so named in more modern days, which was unknown in the reign of James I. when our Bible was translated); and from the same source have been derived the imperishable reds of the Flemish tapestries. The scarlet afforded by cochineal was unknown in its highest perfection till the

[1] See his Memoir in Swedish,—*Om nagra svenska arter of Coccus*, Stockholm, 1826.

[2] Be it remembered, however, that the genus *Chermes* of Linn. corresponds to *Psylla* of Lat. already described, and not to our present species, which are the true *Kermes* of Geoffroy, Réaumur, and Olivier.

[3] Kirby and Spence's *Introd. to Ent.* and Bochart's *Hierozoic.*

year 1630, when the singular power of the oxide of tin in exalting its colours was discovered in Holland; it was soon after communicated to one of the celebrated MM. Gobelins of Paris, and may have contributed to the perfection of their tapestries.[1] Since the preparation of Morocco leather has been established in this country, cochineal has been employed to produce the beautiful colour of what is called red morocco; but in Persia, Armenia, Barbary, and the Greek islands, a similar colour was originally produced by the use of either kermes or lac.[2] The colouring matter of kermes is regarded by Dr Bancroft as identical with that of cochineal, but combined with some astringent matter derived from the tree on which it feeds.

The substance called *lac* is also the produce of an insect of the Coccus kind. It is collected from various trees in India, where it is used in the fabrication of beads, rings, and other ornaments of female attire. When mixed with sand it forms grindstones; and, added to ivory black, and previously dissolved in water with a little borax, it composes an ink which, when dry, is said to be capable of resisting a considerable degree of damp or moisture. In this country, according to the different states in which it is imported, it is called stick-lac, seed-lac, lump-lac, or shell-lac. It is chiefly used in the making of varnishes, japanned ware, and sealing-wax, although during late years it has been applied to a still more important purpose, as originally suggested by Dr Roxburgh, that of a substitute for cochineal in dyeing scarlet. The first preparations from it with this view were made in consequence of a hint from Dr Bancroft; and large quantities of a substance termed *lac-lake*, consisting of the colouring matter of stick-lac, precipitated from an alkaline lixivium by alum, were manufactured at Calcutta, and sent to this country, where at first the consumption was so considerable, that in the three years previous to 1810 the sales at the India house equalled in point of colouring matter half a million of pounds weight of cochineal.[3] "More recently, however, a new preparation of lac-colour, under the name of *lac-dye*, has been imported from India, which has been substituted for the lac-lake, and with such advantage, that the East India Company are said to have saved in a few months L.14,000 in the purchase of scarlet cloths dyed with this colour and cochineal conjointly, and without any inferiority in the colour obtained."[4] The only mordant formerly used with kermes was alum, and the colour communicated was blood-red; but Dr Bancroft ascertained, that with the solution of tin used with cochineal it was capable of imparting as brilliant a scarlet as that dye, and one perhaps more permanent. It must be borne in mind, however, that as ten or twelve pounds of kermes contain no more colouring matter than a single pound of cochineal, the latter at its ordinary price is, after all, the cheapest.

Several other curious and valuable products are obtained from insects belonging to the genus Coccus, or to one nearly allied in its natural character and attributes. The *pe-la*, for example, or white wax of the Chinese, is derived from an insect, apparently a Coccus, described by the Abbé Grozier; and a non-descript Indian species produces a wax analogous to pe-la, first noticed by Dr Anderson under the name of white lac. It is obtained in great quantities in the vicinity of Madras; but Dr Pearson's experiments do not countenance the idea, at one time rather sanguinely entertained, that it might be advantageously used for making candles.[5] Geoffroy long ago attributed to a species of kermes the faculty of producing a sugary substance, of a white colour, resembling manna; and Captain Frederick has described an article of that nature under the name of *Gez*, found in Persia and Armenia; but he seems doubtful whether to attribute to it an animal or a vegetable origin.[6] More recently, however, General Hardwicke has described an Indian insect, under the name of *Chermis mannifer*, of the size of the domestic bug, and of a flattened oval form, with a rounded tail. From its abdomen a quantity of saccharine substance is exuded, and assumes the form of a bunch of feathers, with a consistence like that of snow. These insects are found on the branches and leaves of trees in millions, and they there produce this feather-like secretion, till it becomes elongated, and, dropping on the leaves, hardens upon them into a substance resembling the most beautiful wax.[7]

Of the European species, in addition to *C. Ilicis*, already described, we may mention *C. adonidum*, now naturalized in our hot-houses, where it is very destructive, and *C. polonicus*, which yields a colouring matter almost as beautiful as the Mexican cochineal; it attacks the roots of *Scleranthus perennis*, and other plants, and is still used as a dye in Russia.

Before closing this branch of our subject, we must devote a few lines to the cochineal insect properly so called, the *Coccus cacti* of naturalists (Plate CCXLII. figs. 16, 21, 22). This species, so important in a commercial point of view, and in relation to our arts and manufactures, is a native of Mexico, where it was assiduously cultivated at a period long anterior to the European conquest of that country. We shall not describe its appearance, as that will be better understood by an inspection of the figures just referred to. There are several varieties, named in general from the provinces where they are bred; and of these, that called Mastique or Mèsteque is regarded as the best. It is cultivated on a tree called Nopal by the Indians (*Cactus cochenilifer*, Linn.) and its colour is by some attributed to the juices of that plant. It is the female insect that is so highly valued for the incomparable beauty of its colour. It is imported to Europe in the form of a little grain, convex on one side, concave on the other, and exhibiting traces of the abdominal segments. In the year 1736 there was sent to Europe about 700,000 pounds weight of this minute creature, a quantity worth L.700,000 sterling. Humboldt states the quantity imported about the period of his inquiries to have been 32,000 arrobas, worth in South America L.500,040 sterling,[8]—"a vast amount to arise from so small an insect, and well calculated to show us the absurdity of despising any animals on account of their minuteness."[9] Dr Bancroft calculates the annual consumption of cochineal in Great Britain at about 750 bags, or 150,000 pounds weight,—worth L.375,000 sterling at recent prices. The natives of those districts in which the cochineal is reared form plantations of the nopal tree near their dwelling-houses. It grows freely from cuttings, and the latter are fit for the reception of the insect in eighteen months. Eight or ten females are put into a small nest formed of tufts of a thread-like substance collected from a species of palm,

[1] *Quarterly Review*, vol. ix. p. 210.
[2] *Experimental Researches concerning the Philosophy of Permanent Colours*, &c. by Edward Bancroft, M. D. vol. ii. p. 167.
[3] Bancroft, *ut supra*.
[4] *Introd. to Ent.* vol. i. p. 318.
[5] *Linn. Trans.* 1794.
[6] *Transactions of the Bombay Literary Society*, vol. i.
[7] *Description of Gez or Manna, in the Asiatic Researches*, vol. xiv. p. 182.
[8] *Political Essay on New Spain.*
[9] *Introduct. to Ent.* vol. i. p. 316.

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or of any other cottony matter. These nests are attached to the spines of the nopal, upon the side facing the rising sun, and the insects are placed in them about the middle of October, a period at which good weather usually commences in Mexico after the rains. The eggs are soon laid and hatched, and the progeny spread in vast numbers over the plant, each female producing upwards of a thousand young. According to M. Thierry de Menonville,[1] six generations are produced in a year, and they might be collected at all seasons, but for the destruction produced among them by the periodical rains. The first collection takes place about the middle of December, and the last in the month of May. They are detached by means of a knife with the edge blunted, to prevent injury to the nopal tree. When the first gathering is made, the nests are taken away, and the dead females (those placed on the nopal in October) are likewise picked off. These are lighter and less valuable than such as are taken off alive and full of young; the former losing three fourths, the latter two thirds, during the process of drying. As soon as dried, however, both kinds may be kept for any length of time, without any further loss of either weight or colour. They are killed by different processes. Some put them in a basket, which they dip in boiling water, and afterwards dry them by exposure to the sun; others place them in an oven, or on plates of heated iron. The various external colours of the insect, as we afterwards see it in Europe, depend upon the mode of putting it to death. Those which have been killed by being dipt in hot water (the method regarded as the best), lose a portion of the white powder with which they were previously invested, and acquire a brownish-red colour. When so treated, they pass under the name of *renagrida*. When killed in an oven they retain the white powder, remain externally of a grey colour, and are called *jarpeada*. Such as are placed on plates of heated iron become of a blackish hue, and are then named *negra*. When cochineal insects are forced from the tree, they speedily die, even if no further violence is offered them; because their sucker, being fixed in the wood, is unavoidably dislocated and broken off by the act of removal. It is necessary, however, to put them to death, because they might otherwise live for a short time, and meanwhile produce their young, the loss of which would diminish the quantity of colouring matter.

The other most frequent variety of cochineal is called *sylvester*, on account of its being commonly collected from a species of cactus which grows wild, or without culture. It is of smaller size, and much less valuable in relation both to the amount and quality of the colour which it yields. We have not yet ascertained to our own satisfaction whether it is a mere variety or a distinct species. Although it occurs naturally upon a wild spiny cactus, it is also cultivated upon the nopal or garden species, for the sake of the greater facility of collection. So great indeed is the difference in this point, that in one day a single labourer will gather from the latter a quantity which, when dry, will amount to the weight of three pounds,—whereas from the former the most persevering hand will not obtain in that time much more than a couple of ounces. Moreover, when cultivated on the garden nopal, the *sylvester* cochineal attains to as large a size as the *mastique*.

Various attempts have been made to introduce the culture of the cochineal into our eastern possessions, although these, so far as we are informed, have not yet been attended with any marked success. The old Spanish government manifested great jealousy on the subject; and we are not aware that the true kind has been yet imported, although the court of directors at one period offered a reward of L.6000 to whoever should effect its introduction to India. Colonel Bory St Vincent informs us that attempts have recently been made, and with a fair prospect of success, to effect its cultivation near Malaga, in Spain.[2] We shall conclude our sketch by observing that considerable care is requisite to preserve these insects from the attacks of their natural enemies, of which one of the chief is the larva of a species of Coccinella, which sucks them to death, and leaves nothing but the skin. A very destructive foe is also described as being a caterpillar, of an inch in length, and the thickness of a crow-quill, which, it is said, would soon destroy the race if allowed to continue its attacks without any interference on the part of the higher powers.[3] It is said that a species of *Ptinus* also feeds upon them freely. Besides these direct enemies, there is another insect, with the exact nature of which we are not acquainted, which lives in common with the cochineal upon the juices of the nopal, and by so doing greatly interferes with the health and progress of the more valuable species. Among its larger, if not more formidable enemies, we may mention a mouse, which is said always to prefer the mastique or finer cochineal to the sylvester or wild species, because the cottony matter with which the latter is invested produces discomfort by entangling in its teeth. Both kinds are moreover subjected to the attacks of numerous birds.

Neuroptera.

Order IV.—NEUROPTERA.[4]

Distinguished by four naked or transparent wings, reticulated or interlaced by a delicate network, and usually of the same size as well as texture. The mouth is adapted for mastication, that is, furnished with mandibles and true maxillæ, and never assumes the tubular form. The abdomen does not possess a sting, and is rarely provided with an ovipositor. The antennæ are usually setaceous, and composed of numerous articulations. The head is furnished with two or three simple eyes. The thorax is formed of three segments, intimately united to each other, though perceptibly distinct from the abdomen; the first of these segments is usually very short, and in the form of a collar. The number of joints of the tarsi varies. The form of the body is for the most part elongated, and its texture rather soft and delicate. The abdomen is always sessile. Many of the species are carnivorous, both in the larva and perfect state.

This beautiful and very varied order has been divided into two by Mr Kirby, by the separation of the genus *Phryganea* of Linn., which the English naturalist raises to the rank of an order under the name Trichoptera. It might also have simplified the characters of the order if we had left in it only those which possess reticulated wings; but as some of the latter exhibit a difference in the texture of the organs of flight, it is difficult to assign rigorous characters to the neuropterous tribes, if we attach a high importance to the wings. "Of all the Linnæan orders," says Mr Kirby, "this appears to consist of

[1] *Traité de la Culture du Nopal*, 2 vols. 8vo, Paris 1787. This author endeavoured to introduce the Spanish American cochineal into St Domingo, but they perished for want of care.

[2] *Annal. des Sciences Nat.* t. viii. p. 105.

[3] We scarcely think that the creature above alluded to can be a caterpillar properly so called, that is, the larva of a lepidopterous insect.

[4] Odonata, and the majority of Synistata, of Fabricius.

the most discordant tribes; so that it seems next to impossible to construct a definition that will include them all, unless indeed we admit M. Latreille's idea, adopted by Mr Macleay, that a varied metamorphosis is its essential character; or, to speak more largely, variety itself seems the characteristic of the insects composing it in every state, and there is scarcely a common distinctive character in their perfect state, upon detecting which in any individual, you may exclaim—this is a neuropterous insect."[1] The neuropterous species, however, may be readily distinguished from the orthopterous and hemipterous kinds by the greater difference of consistence in the two latter between the upper and under wings. The Hymenoptera, again, have generally much longer maxillæ—serving rather to suck the juices than to bruise the more solid portions of the substances on which they feed. The scale-covered wings of the lepidopterous order prevent their being confounded with our present subjects; while the Diptera are easily distinguished by the absence of the lower wings, and the different structure of the organs of manducation.

The mouth in the neuropterous order is generally composed of a labrum and a labium, of two mandibles, and a pair of maxillæ. The latter organs are very sharp and strong among the *Libellulæ*, which prey on other insects, but extremely small or almost imperceptible in the *Ephemeræ*, which, as their name implies, are very short-lived, and take no nourishment in the perfect state. The palpi are very short in the former tribes, but exceedingly long among the *Myrmeleones*. Although the antennæ, in the majority, are filiform or setaceous, they are terminated by an elongated club in those last named; while in the genus *Ascalaphus* they are very long and slender, and terminate in a little button, resembling those of many Lepidoptera. The wings are sometimes tectiform or incumbent, sometimes stretched out horizontally. Though frequently alike in size, they occasionally differ from each other. Thus in the genus *Nemoptera* the under pair are very long and narrow, while in some Ephemeræ they are almost obliterated.

In the larva and nympha states these insects are either terrestrial or aquatic, according to their kinds. In the former case some dwell beneath the bark of trees, others move about on twigs and branches, making an unresisting prey of Aphides; while a certain number inhabit sandy soils, where they excavate insidious pit-falls, and seize upon whatever insects venture within the circle of their treacherous toils. The aquatic species dwell in their earlier states in ponds and marshes, and in the shallower and more sheltered parts of lakes and rivers. They then respire by means of organs which exhibit a strong analogy to the gills of fishes, but which Latreille recognises only as exterior tracheal appendages, named false branchia. Many construct very ingenious cases of small stones, shells, and twigs of water-plants, in which they move about in their watery element.

The Neuroptera are, in general, insects of an extremely elegant deportment. They fly with great facility, and are not unfrequently adorned by agreeable and varied colours. Though almost all carnivorous as larvæ, their habits differ greatly in the perfect state. Some undergo a semi-metamorphosis,—others are completely changed, —but all the larvæ are provided with six-hooked feet, which they usually employ in their search for food. Latreille divides the order into three families, which present the following succession of natural affinities. 1*st*, Carnivorous insects, subject to a semi-metamorphosis, with aquatic larvæ; 2*d*, carnivorous insects, subject to a complete metamorphosis, with terrestrial or aquatic larvæ; 3*d*, carnivorous or omnivorous insects, terrestrial, with semi-metamorphosis; 4*th*, herbivorous insects, subject to a complete metamorphosis, with aquatic larvæ, which construct portable domicils. He terminates with such as have the wings the least reticulated, and which bear a resemblance to Phalenæ or Tineites.

FAMILY I.—SUBULICORNES, Lat.

These consist of the *Odonata* of Fabricius, and the genus *Ephemera*. The antennæ are subulate or awl-shaped, scarcely longer than the head, and consist at most of seven articulations, of which the last is setiform. The mandibles and maxillæ are entirely covered by the labrum and labium, or by the anterior or prolonged portion of the head. The wings are always much reticulated, separate, sometimes horizontal, sometimes raised perpendicularly. The inferior pair, though often as large as the superior, are in some instances much less, or even entirely wanting. The real eyes are large and projecting, and have from two to three stemmatic eyes placed between them. They feed on living prey, and pass their earlier states beneath the waters. The larvæ and nymphs exhibit a form somewhat similar to that of the perfect insects, and respire by particular organs placed along the sides or at least the extremity of the abdomen. They creep up the stalks of plants, or otherwise leave their moist abodes, before undergoing their final transformation.

In the great genus Libellula of Linn. (Plate CCXLIII. figs. 1, 2, 3, 4, 6), the mandibles and maxillæ are corneous and very strong, and are covered by the labrum above and by the labium below. The tarsi have three articulations. The wings are nearly of equal size, and the posterior extremity of the body is terminated simply by hooks or by foliaceous appendages.

The light and graceful form of these insects, their beautiful and varied colours, their large and lustrous wings, and the hawk-like velocity with which they pursue their flying prey, render them objects of our frequent attention, and easy to be recognised. Our present observations apply to all the component parts of the great and unrestricted genus just named. We shall afterwards give the specialities of the minor groups. The eyes of the Libellulæ, or dragon-flies in general, are large and lateral; the stemmata are placed upon the vertex. The antennæ are inserted on the front, behind a vesicular elevation, and are composed in the greater number of from five to six articulations, or at least of three, of which the last is composite, and attenuated in the form of a style. The labrum is arched and semicircular; the mandibles are of a scaly texture, very strong and toothed; the maxillæ are terminated by a piece of the same consistence, dentated, spinous, and ciliated on the inner side, with a palpus of one articulation on its back, representing what is called the *galea* in the orthopterous tribes. The labium is large, arched, and trifoliate, the two lateral foliæ being in fact palpi. There exists a kind of epiglottis, or vesicular and longitudinal tongue, in the interior of the mouth. The abdomen, always considerably elongated, varies in its contour, being in some cylindrical, in others compressed, and occasionally flattened. It is terminated in the males by two lamellar appendages, which likewise vary in form according to the species. The legs are short, and directed forwards. " Le dessous du second anneau de l'abdo-

[1] *Introduc. to Ent.* vol. iv. p. 371.

men renferme, dans les mâles, leurs organs sexuels, et, comme ceux de la femélle sont situés au dernier anneau, l'accouplement de ces insectes s'opère différemment que dans les autres. Le mâle, planant d'abord au-dessus de sa femélle, la saisait par le col, au moyen des crochets de l'extrémité postérieure de son ventre, et s'envole ainsi avec elle. Au bout d'un temps, plus ou moins long, celle-ci se pretant a ces desirs, courbe en dessous son abdomen, et en applique l'extrémité sur les parties du mâle, dont le corps est alors courbé en forme de boucle. La copulation a souvent lieu dans les airs, et quelquefois encore sur les corps où ces insectes sont posés."[1] The female deposits her eggs on aquatic plants, by plunging her posterior extremity beneath the water.

The larvæ and nymphs are aquatic. The former have no wings, the latter exhibit them in a rudimentary state (Plate CCXLIII. figs. 1, 3). The head in these early stages is remarkable for the singular piece which corresponds to the labium. It assumes the form of a mask, and covers the mandibles, the maxillæ, and almost all the under parts of the head. It is composed of, 1*st*, a principal triangular piece, sometimes arched, sometimes flat, named *mentonnière* (or chin-cloth) by Réaumur, which articulates by means of a hinge with a pedicle or kind of handle attached to the head; 2*d*, of two other pieces inserted at the lateral and inferior angles of the preceding, moveable at their base, transverse, and either in the form of wide and dentated plates, resembling shutters in their nature, and the mode in which they close the mouth, or analogous to little hooks or claws. To that portion of the mask where the *mentonnière* is articulated with its pedicle, or the knee, and which appears to terminate it inferiorly when the mask is bent or folded upon itself, Réaumur applied the term *mentum*. The insect unfolds and extends this peculiar apparatus with great promptitude, and seizes its prey with the pincers of the superior portion. These creatures live for ten or eleven months in the water, during which period they several times cast their skin. When the nymphs are ready to assume their final change, the form and position of the wing-cases undergo an alteration. They then leave the water, become dry and crisp, the skin of the thorax bursts asunder, and the winged insect issues forth under a different and much more ornamental aspect. The name of *Demoiselles*, by which many of them are known to our continental neighbours, attests the impression produced by their graceful forms or elegant movements. These Demoiselles always come out of the water head foremost; but no sooner have they burst their casements than they turn themselves round, and hang for a time with their head downward, being prevented from falling by the hinder segments of the abdomen being still entangled in and adhering to the skin of the nymph. After a time the young aspirant again turns round, and seizing the anterior portion of the cloven skin with its claws, it finally succeeds in dragging itself forth from its former dwelling. The wings, however, are as yet narrow, thick, and closely folded, just like a leaf during the bursting spring. After another hour or two they become firm, consistent, and extended both in length and breadth, and the gay and gorgeous creature, launching buoyantly into the air, becomes the tyrant of the insect world.

M. Poe, who paid particular attention to the entomology of Cuba, informed Latreille that, at a certain season of the year, the northern winds sweep an innumerable host of a species of dragon-fly into Havannah and its environs.[2]

The Linnæan genus LIBELLULA is now divided into three.[3] In LIBELLULA[4] proper (Pl. CCXLIII. fig. 2), the wings are extended horizontally in repose, the head is almost globular, with the eyes contiguous or approximate. There is a vesicular elevation, with a stemmatic eye on each side upon the vertex; the other stemmatic eye is larger, and placed anteriorly. The central division of the labium is much smaller than the lateral ones, which unite above by a longitudinal suture, and exactly close the mouth. The abdomen is usually ensiform, and flattened. The larvæ and nymphs (ibid. fig. 1) have five appendages to the posterior extremity of the abdomen, which combine to form a pointed tail; their body is short, and the part named *mentonnière* by Réaumur is arched in the form of a helmet, with the two lateral pieces in the form of shutters. We may mention *L. depressa*, Linn. (the species figured), as a British example of the genus. In ÆSHNA, Fab. the species resemble the preceding in the position of the wings and the form of the head, but the posterior stemmatic eyes are placed upon a simple transverse elevation or keel. The intermediate lobe of the labium is also larger, and the other two are distant, and armed with a very strong tooth, and a spinous appendage. The abdomen is always narrow and elongated. The form of the larvæ and nymphs is also more lengthened than that of the same states in Libellulæ. The mask is flat, and the two pincers are narrow, with a moveable nail at the end. The abdomen, in their early states, is also terminated by five appendages, one of which, however, is truncated at the point. *L. grandis*, Linn. the largest and one of the swiftest and most powerful and predaceous of the British species, belongs to this genus. In AGRION,[5] Fab. Plate CCXLIII. fig. 6), the wings are held perpendicularly in repose, the head is transversal, and the eyes distant. The form of the labium is analogous to that of Æshna, but the middle lobe is divided into two as far as its base. The third joint of the lateral lobes is in the form of a membranous ligula. The antennæ seem to be composed of only four joints. The front presents no vesicle, and the stemmatic eyes are of nearly equal size, and disposed triangularly on the vertex. The abdomen is very slender or even filiform, and, in some foreign species, of extraordinary length. That of the female is furnished with serrated laminæ at its posterior extremity. The form of the body in the larva and nympha states of this genus is likewise long and slender, and the abdomen is terminated by three fin-like plates (ibid. fig. 3). The mask is flat, the upper extremity of the *mentonnière* being raised to a point in some, and forked or sloped in others; the pincers are narrow, but terminate in several dentations resembling hands. The species are very numerous. *A. virgo* has dark-coloured wings, and a lustrous metallic body, varying from golden green to greenish blue. Its flight is irregular and rather heavy. To this genus also belong the small pale-coloured kinds, annulated with black, and presenting a considerable range of variation even among individuals of the same species, besides the more fixed distinctions of a sexual character.

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[1] *Règne Animal*, t. v. p. 237.

[2] *Ibid.* t. v. p. 238.

[3] The structure of the eyes in dragon-flies is described by Cuvier in the *Mém. de la Soc. d'Hist. Nat. de Paris*, t. i. In addition to the ordinary systematic works, the student of the species should attend particularly to a monograph on European Libellulæ, published in the *Horæ Entomologicæ* of M. Toussaint de Charpentier, another monograph on the same by M. Vander Linden, and a memoir by the latter author on the species which occur in the territory of Bologna.

[4] Named probably from the Latin *Libellus*, a little book, on account of the page-like expansion of the wings.

[5] From ἄγριος, *cruel* or *ferocious*.

Neuroptera.

In the other Neuroptera of the family Subulicornes the mouth is entirely membranous or very soft, and composed of not very distinguishable parts. Their tarsi consist of five joints. The inferior wings are much smaller than the upper ones, and are even sometimes wanting. The abdomen is terminated by two or three setæ. They form the old genus EPHEMERA[1] of Linn., (Pl. CCXLIII. figs. 5, 7, and 9.

In these frail and fleeting insects the body is very soft, long, and tapering, and terminates as above mentioned. Their antennæ are very small, and composed of three articulations, of which the last is very long, and in the form of a conical thread. The anterior portion of their head projects in the manner of a clypeus, is frequently carinated and emarginate, and covers the mouth, of which it is difficult to distinguish the structure, on account of the slight development of its parts, and the softness of their texture. The Ephemeræ in repose carry their wings almost always in a perpendicular position, or a little inclined backwards. The legs are slender, with very short tibiæ, frequently confounded with the tarsi, which often exhibit only four joints, owing to the evanescence of the first; the two hooks of the last are much compressed into the form of a little pallet. The two anterior legs are much longer than the others, inserted almost beneath the head, and extended forwards. These insects usually make their appearance in the winged state towards the evening in fine summer weather, and sometimes in such abundance, that in certain districts of France cart-loads of them have been gathered from the ground, and employed as manure. *E. albipennis*, in particular, a species, as its name implies, remarkable for the whiteness of its wings, sometimes rises and falls in such quantities by the banks of rivers, as to thicken the air and whiten the surface of the ground,—reminding one, even in the verdurous and leafy summer, of

The flaky weight of winter's purest snows.

The males are distinguished from the females by a pair of articulated hooks, and their fore legs and caudal appendages are likewise longer. Although strictly ephemeral in their final state, they have rather a more extended term of life than usual in their subaqueous abodes, where they are said to live and prosper for two or three years. In the larva state the antennæ are longer than afterwards; the stemmatic eyes are wanting; the mouth presents two horn-like projections, which are regarded as mandibles; the abdomen is furnished on each side with a range of laminæ or leaflets, usually united at the base in pairs. These last-named parts are a kind of false branchia, on which the tracheal ramifications are extended, and which serve not only for the purposes of respiration, but also for those of locomotion. The tarsi have only a single hook at their extremity. The abdomen is terminated by setæ, of the same amount as in the perfect insect. The nymphs differ from the larvæ chiefly in being possessed of little sheaths or wing-cases (Plate CCXLIII. fig. 10). When *ripe*, they leave the waters, and undergo their final transformation, pretty much after the manner of the Libellulæ already described, although more rapidly. One singular characteristic, however, attends their winged condition, from which the other tribes are free; they cast off a complete envelope or skin, including that even of the limbs, setæ, and antennæ, almost immediately after they have attained the perfect state, or at least what Mr Curtis has well named the *pseudo-imago*. While following the delightful pursuit of angling, both along our own unrivalled streams, and by the banks of foreign waters, we have frequently had our fishing panier and the rims of our hat covered by a pearly layer of these ghost-like exuviæ, and it proved extremely interesting to witness what we had often previously perused in the accurate pages of Réaumur. Swammerdam, who had long ago observed and described this singular moulting, seems to think that the male sex is alone subjected to it. The manners and metamorphosis of these insects have been minutely detailed by the laborious author just named, in his *Biblia Naturæ*, as well as by Réaumur and Degeer, in their respective *Mémoires* on the natural history of insects. The angler recognises them under the name of May-flies,—an imitation of which, during the early part of the trouting season, is deemed a lure not to be resisted by the finny race. We cannot here describe the species in detail. We have figured several different kinds on (Plate CCXLIII. Some have four wings, figs. 5 and 9; others have only two, fig. 7. Of the latter the eyes are sometimes very singularly constructed; being double, or two on each side, one above the other, as shown by fig. 8 of the same plate.

FAMILY II.—PLANIPENNES.

Latreille here includes those neuropterous species of which the antennæ, always composed of a great number of articulations, are considerably longer than the head, without being styliform or awl-shaped. The mandibles are very distinct, and the under wings, almost equal to the superior ones, are extended, or simply folded beneath at their inner margin. The wings are very generally much reticulated and naked, with the maxillary palpi for the most part filiform, or a little larger at the extremity, shorter than the head, and composed of from four to five articulations. These insects are divisible into five sections, which compose, in relation to their natural habits, an equal number of small sub-families, as follows.

SECTION 1ST, PANORPATÆ.

Characterized by five articulations to all the tarsi, and by having the anterior extremity of the head prolonged and narrowed, in the form of a beak or proboscis. These constitute the old genus *Panorpa* of Linn., commonly called scorpion-flies, probably from the peculiar turning up of their tails (Pl. CCXLIII. figs. 13 and 20). The antennæ are setaceous and inserted between the eyes. The clypeus is prolonged into a corneous lamina, arched beneath for the reception of the mouth. The mandibles, maxillæ, and labium, are almost linear (Plate CCXLIII. fig. 16). The palpi, varying in number from four to six, are filiform; those of the maxillæ do not distinctly present more than four joints. The body is elongated, the head vertical, the first segment of the thorax usually very small, and in the form of a collar. The abdomen is conical or almost cylindrical. In several species the sexes are very dissimilar. Naturalists do not as yet appear to have acquired any knowledge of their transformations. They are now divided into the following genera:- NEMOPTERA,[2] (Plate CCXLIII. fig. 11), BITTACUS, PANORPA proper (ibid. fig. 13), and BOREUS. The type of the last-named genus, and the only species known, is the *Panorpa hyemalis* of Linn. a small insect scarcely a line in length, of a cupreous black colour. It lives among moss in the northern parts of Europe, and is also found in the Alps, not far from the region of perpetual snow.

[1] Named, in allusion to the seeming shortness of their lives, from ἐφήμερος, *that which lasts a day.*

[2] From νῆμα, *a thread*, and πτερα, *wings.*

Section 2d, Myrmeleonides, Lat.

These are also characterized by five articulations to all the tarsi; but they differ from the preceding in not having the head prolonged in the form of a beak or proboscis. The antennæ are gradually enlarged, or have a globular or button-like termination. The head is transverse, vertical, and exhibits no stemmatic eyes. The ordinary organs of vision are round and projecting. The mouth is furnished with six palpi, of which the labial are usually longer than the others, and somewhat inflated at the extremity. The palate of the mouth is raised in the form of an epiglottis. The first segment of the thorax is small. The wings are equal, elongated, tectiform, or incumbent. The abdomen is generally long and cylindrical, with two projecting appendages at the extremity in the male sex. The legs are short.

These insects affect warm places, and are consequently more frequent in the southern countries of Europe than in the chilly regions of the north. They rest on plants, and generally remain quiescent during the day. The nymphs are inactive; but the generality of the perfect insects are well endowed with the power of flight. They form the old genus *Myrmeleon* of Linn., which Fabricius and Latreille have divided into two.

In Myrmeleon[1] proper (Pl. CCXLIII. fig. 12), the antennæ are short, gradually thickened or almost fusiform, and hooked at the extremity. The abdomen is long and linear. The singular larva of one of these insects (ibid. fig. 14) has been attentively studied by Poupart, Vallisnieri, Roesel, Réaumur, and others. It is rather more than half an inch in length, of an oval depressed form and greyish colour. It feeds chiefly on Solomon's emblem of industry, and has hence received the name of *Formica-Leo* or lion-ant. Its head is very small, but armed with two strong and lengthened mandibles, serrated on the inner side, and pointed at the end. These parts look rather like a pair of horns than organs of manducation; but it is with them that the larva seizes upon its prey; and as they are pierced at the extremity, they no doubt also act as suckers. As its form does not admit of active locomotion, nature has made amends by endowing this insect with admirable instinctive skill and cunning. It constructs, in a dry or sandy soil, a funnel-shaped excavation, the sides and edges of which are loose and crumbling, and at the bottom of which, with body closely covered, but with ever-ready jaws projecting upwards, the insidious larva lies concealed. No sooner does an industrious ant, laden perhaps with its republican provision, approach the edge of the unsuspected slope, to it as dangerous as a volcanic crater or avalanche of snow, than the finely poised sand immediately gives way, and the persevering citizen, rolling to the bottom, is instantly seized and sucked to a shadow by the lurking tyrant. The dead body is ere long tossed by a jerk of the head beyond the immediate boundaries of the dwelling, probably because it is by this time useless, or, as some French naturalist has expressed it, "pour que son cadavre n'épouvante pas les autres fourmis qu'il attend." There are tartars, however, among Myrmeleons as well as men; and it sometimes happens that a large and vigorous winged insect, such as a wasp, bee, or beetle, tumbles head foremost into the pit. "When Greek meets Greek, then comes the tug of war;" and when a lion-ant has the tail of a wasp in his mouth, there is no saying exactly how the combat may end. The one is furnished with jaws tenacious as well as strong,—but he bears no "charmed life;" while the other is armed with a weapon which the dews of heaven cannot rust, and compared with the keenness of which the brightest sword in Damascus is as a broken foil. In these doubtful, though, to one or other of the parties, eventually disastrous circumstances, the result at last is, that either the lion-ant is dragged out of his den and stung to death, or dropped upon the ground and left a prey to birds, or that the winged insect is maimed, disabled, drawn into the sand, and slain. If an insect incapable of flight, or from its situation unable to use its wings, but of larger size than the Myrmeleon deems it prudent at once to seize upon, chances to fall into the snare, it is overwhelmed in its attempts to re-ascend, by repeated showers of sand, which its enemy directs upon it with unerring aim. No sooner, however, is the strength of the toiling and exasperated Sisyphus at least in part exhausted, than he too is seized upon, and sucked to death. The lion-ant makes use of its head as a catapult or instrument of war, with which to shower the sand upon its astonished prey. This singular larva is capable of enduring a very long-continued fast. When it has attained to the natural term of its increase, which requires the lapse, it is said, of nearly a couple of years, it weaves a white cocoon, by means of two spinners placed at the posterior extremity of the body, of a rounded form and satin lustre, but covered with grains of sand. In this it undergoes its transformation to the nympha state (Pl. CCXLIII. fig. 15). The perfect insect bursts from its silken tomb in the course of from fifteen to twenty days. We are acquainted with many species of the genus. Besides the one of which we have just now sketched the history, and which is the *Myrmeleon formicarium* of systematic writers, another noted species, named *M. Libelluloides*, occurs in the south of France. It is a very large insect, measuring from four to five inches between the tips of the extended wings, and was described as a *Hemerobius* by Linnæus. It is the *Libella turcica* of old Petiver, and the *Musca rarissima* of Ray. We were once nearly drowned in trying to capture it by the side of a muddy stream. The flight of both of these insects, and of all belonging to the genus, is slow and heavy. They seldom fly far, and seem to end their lives near the places where they had their birth,—even to the last "loving the spots which once they gloried in." They are unknown in Britain.[2]

In the genus Ascalaphus,[3] Fab. (Pl. CCXLIII. fig. 19), the antennæ are very long, and terminate somewhat abruptly in a club or expansion. The wings are proportionably broader than those of Myrmeleon. The flight of these insects is rapid and light. They occur chiefly in the warmer parts of Africa and America, although a few are found in Europe. Of these *A. Italicus* occurs in France as far north as the environs of Fontainebleau. We have no very precise knowledge of their transformations. They do not occur in Britain.

Section 3d, Hemerobini.

The component parts of this group resemble those of the preceding in the general form of the body and wings; but the antennæ are filiform, and the palpi only four in number. They form the old genus *Hemerobius* of Linn. and Fab. which has since been subdivided as follows:—

In Hemerobius proper (of Lat.) the first segment of the thorax is very small, the wings incumbent, and the last article of the palpi is the thickest, ovoid, and pointed.

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[1] From μυρμηξ, *an ant*, and λεων, *a lion*.

[2] *M. formicarium* holds a *nominal* place as a British insect; but we have never felt *assured* of its existence as an indigenous species.

[3] Ασκαλαφος is the ancient mythological name of a bird. We do not know for what reason it was applied to the above genus.

Neuroptera.

The larvæ are terrestrial, that is, not aquatic. They wander about from place to place, committing great havoc among Aphides, their favourite food,—for which reason they are named *lions des pucerons* by Réaumur. These they seize by means of their horn-like mandibles, and speedily suck to death. Some of the perfect insects are exceedingly beautiful, especially a well-known British species called *Hemerobius perla*, which is of a pale yellowish green, with delicately transparent yet lustrous wings, and brilliant golden eyes. Its flight is feeble. The females lay their eggs on leaves, to the number of twelve or sixteen in a group. They are whitish and oval, and are supported and secured by a long hair-like stalk or pedicle, which some botanists, less versed in edible fungi than Dr Greville, have mistaken for a species of *mushroom!* (See Pl. CCXLIII. fig. 21.)

Other allied species have the first segment of the thorax large, with the wings usually placed upon the body in a horizontal position. The palpi are filiform, with the last article conical, or almost cylindrical, and frequently shorter than the preceding. The larvæ are aquatic. These insects were placed by Fabricius, along with the species of the genus *Perla* of Geoffroy (from which, however, they differ in the number of articulations of the tarsi), under the genus SEMBLIS, which is itself composed of CORYDALIS, CHAULIODES, and SIALIS, of Latreille.[1]

SECTION 4TH, TERMITINÆ.

This group comprises such Neuroptera as are subject to a semi-metamorphosis, and are active and carnivorous, or rather omnivorous gnawers, in all their states. With the exception of the Mantispæ, which, in regard to their anterior legs, resembling those of the Mantides, are peculiar in their order,—the tarsi have at most four articulations, in which they differ from the preceding genera of the family with which we are still engaged. The mandibles are always corneous and strong.

Some possess tarsi consisting of from five to three articulations, with very distinct and projecting labial palpi. The antennæ are generally composed of more than ten joints, the prothorax is large, in the form of a corselet, and the wings are of equal size, and much reticulated.

In the genus MANTISPA of Illiger (*Rhaphidia*, Scopoli, Linn.; *Mantis*, Fab. Oliv.), all the tarsi have five articulations, and the anterior legs, like those of Mantis, are adapted for prehension. The antennæ are very short and granose, the eyes large, the prothorax very long, thickened anteriorly, and the wings incumbent. This genus consists of not more than five or six species, only one of which, *M. pagana*, is found in Europe. In the genus RAPHIDIA,[2] Linn. Fab. (Pl. CCXLIII. fig. 24), the tarsi have only four articulations. The wings are incumbent when at rest, the head elongated, and narrowed posteriorly, the thorax long, narrow, and almost cylindrical. The abdomen of the female is terminated by a long exterior oviduct, formed by a couple of laminæ. The species figured on the plate referred to is well known in Britain. It lives in woods. Both the larva and imago feed on other insects. The former is lively in its movements when disturbed. It lives in the fissures of trees, and has the form of a little serpent. In the genus TERMES, which contains the famous white ant (Pl. CCXLIII. figs. 17, 18, and 23), the tarsi are likewise composed of four joints, but the wings are very long, and are horizontally spread upon the body. The head is rounded, and the thorax almost square or semicircular. The body of these insects is depressed, and the antennæ, at least in the females, are short, and formed like a chaplet. The mouth resembles that of the orthopterous order, and the labium is quadrifid. There are three ocelli, one of which, placed upon the front, is indistinct, and the other two are placed laterally, near the internal margin of the ordinary eyes. The wings are usually rather transparent, colourless, with fine and close-set nervures, but not very distinctly reticulated. There are two small conical biarticulated points at the extremity of the abdomen. The legs are short. A good monograph of this singular and destructive genus is still a desideratum in Entomology. Several species, inhabiting widely distant countries, have been described under the general name of *Termes fatale*, but we have still an insufficient knowledge of their actual and distinguishing characteristics. So confused was the acquaintance of our immediate predecessors with these insects, that the larvæ of *T. flavicolle*, Fab. were placed by Linnæus among his *Aptera*, while the perfect insects formed a part of his genus *Hemerobius*. These Termites are for the most part peculiar to countries placed between or near the tropics. The individuals named neuters or labourers among the white ants (commonly so called) are the wingless larvæ (fig. 17), and in that state their powers of destruction are quite appalling. They live together in assemblages so vast as almost to defy calculation, and excavate galleries under ground, in trees, tables and all kinds of furniture, as well as in the timber of dwelling-houses. Dr M'Murtrie saw a beautiful edifice in the Isle of France that had been abandoned within a few months after its completion, on account of the attacks of these destructive creatures. The whole building was a mere shell.[3] Whatever ligneous bodies are mined by them, retaining little but a superficial bark, soon crumble into dust; and where the roof of a house, or heavy lintel stone, depends on such support, the insecurity may be as easily imagined as described. They sometimes construct external tunnels or covered ways, which conceal them from view while passing to and from their subterranean dwellings. Sometimes their habitations are raised pyramidally above the surface, in other instances they resemble turrets, with an eave-like expansion on the top. Some are broader and extremely solid; and when constructed, as they often are, in groups, they exhibit the appearance of a little village. They are so strongly built, that when raised to only half their height, they are capable of supporting such wild bulls as mount upon them to act as sentinels while the rest of the flock is feeding. When at their full height of ten or twelve feet, they are used by men as stations from which to look across the country, the grass itself being in those regions of equal height. Smeathman, to whom we owe a curious and often-quoted narrative of their history, has frequently stood with four companions on the top of one of their buildings, employing it as a watch-tower by the shore, from which to obtain sight of whatever vessels might heave in sight. Besides the larvæ or workers, we find another set of inhabitants, of which the nature is not yet clearly known, although their functions are obvious. They are known by the name of soldiers or neuters, and were erroneously regarded by Fabricius as the nymphs. They defend the habitation. When a breach is effected with a pick-axe, they make their appearance, and snap about in all directions with their mandibles,—apparently in a state of considerable indignation. When the attack has ceased, the soldiers retire, and are succeeded by the labourers, who speedily repair the breach. They are still attended, however, by a few soldiers, who seem to act as superintendents of the work. The nymphs bear the rudi-

Neuroptera.

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[1] See *Règne Animal*, t. v. p. 252.

[2] From ῥαφις ιδος, *a needle*.

[3] Cuvier's *Animal Kingdom*, American edition, vol. iv. p. 73.

Neuroptera.

ments of wings; in other respects they resemble the larvæ. No sooner do they become perfect, by acquiring the organs of flight, than they wing their way from their original dwellings, during the evening, or the stillness of night, and in incalculable numbers. At sunrise, however, by a singular law of nature, they lose their wings, which dry up, become shrivelled, and fall to the ground. In this defenceless state they become the prey of many reptiles, and of insect-eating birds. Indeed they seem not to be despised in that respect even by man himself; for not only are they greedily devoured by Hottentots and negroes, but have been often eaten by Europeans with delight. Mr Smeathman found them " delicate, nourishing, and wholesome, without sauce or other help from cookery, than merely roasting them in the manner of coffee." He indeed discoursed with various friends on the taste of white ants, and on comparing notes, they agreed that these insects were " delicious and delicate eating." One gentleman compared them to sugared marrow, while another thought they tasted like " sugared cream and a paste of sweet almonds."[1] Although prodigious numbers perish in consequence of this migratory instinct, such are their vast powers of fecundity, that old colonies are soon replenished, or new ones formed. According to Smeathman, the provident larvæ seize upon all the winged couples they can find, and shut them up in a roomy cell or nuptial chamber, where they supply them with abundant food; " mais j'ai lieu de présumer," says Latreille, " que l'accouplement a lieu, comme celui des fourmis, dans l'air ou hors de l'habitation, et que les femelles occupent seules l'attention des larves, dans le but de former une nouvelle colonie." The abdomen of the pregnant female (Pl. CCXLIII. fig. 23) becomes so greatly dilated as to exceed the rest of her body by 1500 or 2000 times, and she is then about a thousand times heavier than her husband. Indeed well she may, if, as is reported, she is endowed with the power of laying *thirty-one million five hundred and thirty-six thousand* eggs in the course of a year. Those fond of arithmetic may try to discover how many grandchildren she is likely to possess by the termination of the ensuing season.

Certain Termites (*T. arborum*) live on trees, where they build nests as large as sugar casks, and from seventy to eighty feet above the ground. These are formed of particles of gnawed wood cemented by a gluten either secreted by themselves, as silk is by caterpillars, or gathered from gummiferous trees. They are so strongly attached to their supporting branches as to resist the violence even of those tornadoes which so often in tropical countries level alike the palaces of kings, and " huts where poor men lie." Indeed they cannot be detached except by being hewn in pieces. The genus Termes is not unknown in Europe. *T. lucifugum* of Rossi (*Faun. Etrusc.*) occurs in the southern provinces of France, where it dwells in the interior of various trees. It has so greatly multiplied in the workshops and storehouses of the navy-yard of Rochefort that it cannot be extirpated, and is the cause of constant damage. *T. flavicolle* proves extremely injurious to the olive trees in Spain. Our " favoured isle" is fortunately free from these and many other continental pests,—if an entomologist may so express himself regarding species which would no doubt be highly prized *as British* by many a fond collector.

The remaining Termitinæ are characterized by their biarticulate tarsi, and their short and indistinct labial palpi. The antennæ consist of about ten joints; the anterior segment of the thorax is very small; and the inferior wings are less than the superior. They form the genus Psocus of Latreille, which consists of very small species with short soft bodies, often hunched or inflated, with a large head, setaceous antennæ, projecting maxillary palpi, and incumbent wings, slightly reticulated or but simply veined. These are active insects, living beneath the bark of trees, in wood, straw, &c. Some occur among books and in collections of plants and insects. They seem peculiar to Europe. *P. pulsatorius* derives its name from the sound, resembling the ticking of a watch, which, in common with some other insects, it utters in our apartments. Its anatomy is described by Germar.[2] We have many British species.

Section 5th, Perlides.

Of these the tarsi are furnished with three articulations, and the mandibles are almost always partly membranous and small, with the inferior wings wider than the superior, and doubled on themselves at their inner edge. The genera are Perla of Geoffroy, and Nemoura[3] of Latreille (*Phryganea*, Linn.).[4]

FAMILY III.—PLICIPENNES.

The insects of this family have no perceptible mandibles. Their inferior wings are usually broader than the upper ones, and longitudinally plaited. They compose the genus Phryganea[5] of Linn. divided by Latreille into Sericostoma[6] and Phryganea proper (see Plate CCXLIII. fig. 26). In the larva state (figs. 22 and 25) they live in tubes or cases of their own construction, made of a great variety of substances, according to the species. Latreille regards them as simply herbivorous, although other authors maintain that, in addition to aquatic plants, they prey upon the larvæ of gnats and dragonflies.

We shall conclude our sketch of this order by observing that the characters and habits of the genus Phryganea being very peculiar, the species have in recent times been separated from the neuropterous tribes, and erected into an additional order, Trichoptera, Kirby, so called from θρίξ, τριχος, *hair*, in allusion to the usual roughness of the wings. Both Réaumur and Degeer had previously observed that they were allied to the lepidopterous order. " Although some other insects," Mr Kirby has remarked, " (*Myrmeleon* and *Hemerobius*), placed in the *Neuroptera*, do not agree with the rest in their metamorphosis, yet in their perfect state they exhibit the principal characters of the order, and therefore are properly retained in it; but *Phryganea* differs from the rest both in metamorphosis and characters. Its metamorphosis is very peculiar, the larva imitating many of the *Tineæ*, in constructing, of various materials, a kind of case for its habitation, from which circumstance they are commonly called *case-worms;* and the pupa, which is *incomplete*, and at first quiescent, just before its final change, by a wonderful provision of an all-wise Creator, becomes locomotive, that it may place itself in a situation of security out

[1] *Phil. Trans.* vol. lxxi. p. 169, note. The reader will find a good summary of their history in a more accessible work, " Insect Architecture," in the *Library of Entertaining Knowledge.*

[2] *Magazin der Entomologie*, vol. iv.

[3] From νημα, *a thread*, and οὐρὰ, *tail.*

[4] See *Gen. Crust. et Insect.* t. iii. p. 210; *Règne Animal*, t. v. p. 258; *Encyclop. Méth.* art. Nemoure; and *Mémoire sur les Larves de Nemoures*, par F. T. Pictet, in the *Ann. des Sciences Nat.* t. xxvi. p. 369.

[5] From φρυγανιον, *a faggot*, in allusion, we presume, to the usual aspect of their dwellings while aquatic larvæ.

[6] From σηρικον, *silk*, and στόμα, *the mouth.*

of the water before it casts its exuviæ; and for this purpose the antennæ and the four anterior legs are not confined under the general envelope, though each has its peculiar integument, so that the animal can use them when the time comes for it to emerge from the water, and commence a denizen of the air. The imago exhibits few or none of the characters of the other *neuropterous* genera. The wings are veined in a peculiar manner, without reticulations, in some degree like those of *Lepidoptera*. The antennæ resemble much those of the Tinea tribe, and the tibiæ of many of them are armed with the two pair of spurs observable in so many of the moths; but they have no spiral tongue, the wings, though hairy, have no scales, the under wings are folded longitudinally, and the head, besides the usual compound eyes, has three stemmata. If these remarks appear to entomologists well founded, and it be thought right to consider *Phryganea* as constituting a new order, I think it might be distinguished, since the names of all the known species are hairy, by the name of *Trichoptera*."[1]

Order V.—HYMENOPTERA.[2]

This order, of more direct utility to man than many others, in as far as it contains the species which yield us wax and honey, is characterized, like the preceding one, by the possession of four membranous and naked wings. The mouth consists of mandibles, maxillæ, and an under and an upper lip. The organs of flight, however, differ from those of the Neuroptera, in being simply veined rather than reticulated; and the upper wings are always somewhat larger than the under pair. The abdomen of the female is terminated either by an ovipositor or sting. Besides the ordinary visual organs, these insects are all provided with three small stemmatic eyes. The antennæ are variable, not only in different genera, but in different sexes of the same species. In the majority, however, they are filiform or setaceous. The maxillæ and the labium are generally long and narrow, fixed in a deep cavity of the head by lengthened muscles, semi-tubular at their lower portion, often folded at their extremity, and serving rather for the transmission of nutritive juices than for mastication properly so called. Indeed in several these parts unite to form a kind of trunk or sucker. The ligula is membranous, whether widened at the extremity, or long and filiform, with the pharynx at its anterior base, and frequently covered by a kind of sub-labrum or epipharynx. The palpi are four in number, two labial and two maxillary. The thorax as usual consists of three segments, of which the foremost is very short, and the two remainder are intimately united. The wings cross each other horizontally over the body, and the upper pair have a little rounded convex knob at their base. The abdomen is composed of from five to nine segments, the number being frequently six in the females and seven in the males. It is usually suspended, as it were, to the thorax by a small and slender pedicle; in which case its second articulation seems to be the first, the latter being in fact confounded with the metathorax. The ovipositor and the sting (both being constructed on the same model) are composed, in the generality, of three long and slender pieces, two of which serve as a sheath for the third, which is itself, when under the form of a sting, composed of a pair of pieces joined in one. The tarsi are composed of five articulations, none of which is divided.

The structure of the wings of Hymenoptera has served as the basis of a noted method for their classification, made known by M. Jurine.[3] This method is founded on the nature and number of the nervures of the wings, and of the cells or intermediate diaphanous spaces formed by their ramification. The nature of our present treatise, which we have already extended to the proposed limits (and we are still far from our conclusion), will not, however, admit of our entering fully into such details.[4]

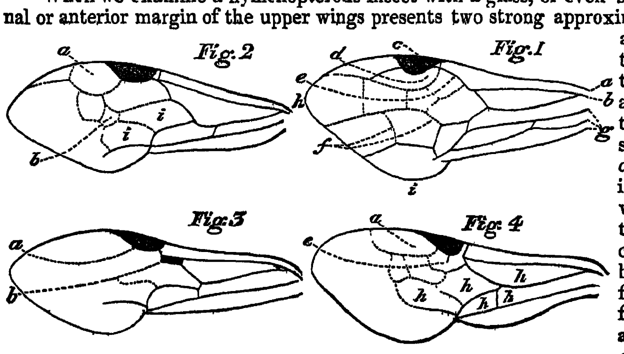
The digestive system of Hymenoptera consists in general of two stomachs, of which the second is elongated; of a short intestine, terminated by a widened cloaca; and of numerous biliary vessels, inserted near the pylorus. In regard to their tracheal apparatus, M. Leon Dufour has remarked, that all the Hymenoptera which he has examined exhibit a greater degree of perfection in that part of their structure than any other order of insects. Instead of being composed of cylindrical and elastic vessels, of which the diameter decreases by successive divarications, they present constant dilatations, or determinate vesicles, favourable to the greater or less continuance of air, and capable of being distended or otherwise, accord-

[1] *Linn. Trans.* xi. p. 87, note.

[2] Piezata, Fab.

[3] *Nouvelle Méthode de classer les Hyménoptères et les Diptères*, 1 vol. in 4to, Geneva, 1807. See also, by the same author, *Observations sur les Ailes des Hyménoptères*, in the 24th vol. of the *Mém. de l'Acad. des Sciences de Turin.*

[4] When we examine a hymenopterous insect with a glass, or even by means of the unaided sight, we shall observe that the external or anterior margin of the upper wings presents two strong approximate parallel nervures, deriving their origin from the thorax, and united by means of a strong expansion of the membrane of the wing. The external nervure is called the *radius*, fig. 1, *a*; the internal the cubitus, fig. 1, *b*. Each of these terminates in a dark-coloured expansion called the stigma, fig. 1, *c*. Besides these larger nervures, which some call *primitive*, several others spring likewise from the base of the wing, and are named *brachial*, fig. 1, *g*. All these principal branches give rise to shorter intersecting nervures, the interlacement of which partitions the wing as it were into membranaceous departments, designated by the name of cells. Several of these, by reason of their constancy of disposition in each genus of hymenopterous insects, have been used with advantage by Jurine for the purposes of classification. A nervure, called the *radial* (fig. 3, *a*), usually springs from the middle of the stigma, and attaining the tip or anterior angle of the wing, leaves between itself and the anterior margin a membranous space, known as the *radial cell* (fig. 4, *a*). If there should, moreover, spring from the stigma a lesser nervure, dividing the cell into two parts, we recognise a pair of radial cells. In this case, however, the larger nervure does not derive its origin from the central line of the stigma, but farther back, or from its basal portion (fig. 1, *d*). It sometimes also happens that the radial nervure, proceeding from the stigma, encounters, before it gains the margin of the wing, a small intersecting nervure, itself proceeding from that margin. The radial cell is then said to be appendaged (*appendicée*), fig. 2, *a*.



Another range of cells, of some importance, has received the name of *cubital* (fig. 1, *e*). It is formed by the posterior edge of the radial nervure, and by another nervure named the *cubital*, which springs from the extremity of the cubitus, near the stigma, and

ing to the quantity of their contents. On each side of the base of the abdomen there is a large oval vesicle of the kind alluded to, of a dull milky white, giving rise here and there to radiating bundles of vascular tracheæ, which distribute themselves to the neighbouring organs. On entering the thorax it becomes restricted, is again dilated, and ends insensibly in a tube, of which the subdivisions are lost in the head. Behind these two abdominal vesicles the respiratory organ is prolonged in the shape of two filiform tubes, which give off an infinity of little air-bearing branches, and become confluent towards the anal extremity.[1]

Hymenopterous insects undergo a complete metamorphosis. Most of the larvæ resemble little worms, unprovided with feet. At least those of the second and following families answer that description. Those of the first family, however, have six feet, furnished with hooks; and besides these they frequently possess from twelve to sixteen others of a simply membranous texture. These latter larvæ are named by the French *fausses chenilles*. Both kinds are provided with a scaly head, with mandibles, maxillæ, and a labium, at the extremity of which is a *spinner* for the passage of that silky substance which is ere long employed in the construction of the nymph's cocoon. Some live on vegetable substances; others, and these are the footless or apodal kinds, feed on insects, with which they are supplied by the provident attention of their mothers, which either carry food to their admirably constructed dwellings, or, as among the Ichneumonides, deposit their eggs at once on living larvæ, of which the excluded young soon become the tenacious and destructive parasites. Among bees a vast number of individuals of ambiguous or undeveloped sex are charged, among other arduous labours, with the sustenance of the helpless young, a task performed with a propriety and precision which, with their many additional attributes of instinctive skill, render their proceedings worthy to be classed, if not as standing miracles of nature, at least as deserving the careful contemplation of the wisest minds.

Happy if full of days—but happier far,
If, ere we yet discern life's evening star,
Sick of the service of a world that feeds
Its patient drudges with dry chaff and weeds,
We can escape from custom's idiot sway,
To serve the sovereign we were born to obey.
More sweet to muse upon his skill display'd
(Infinite skill) in all that he has made!
To trace, in nature's most minute design,
The signature and stamp of power divine,
Contrivance intricate, express'd with ease
Where unassisted sight no beauty sees,
The shapely limb, the lubricated joint
Within the small dimensions of a point,
Muscle and nerve miraculously spun,
His mighty work, who speaks—and it is done,
The Invisible in things scarce seen reveal'd,
To whom an atom is an ample field:
To wonder at a thousand insect forms,
These hatch'd, and those resuscitated worms,
New life ordain'd and brighter scenes to share,
Once prone on earth, now buoyant upon air,
Whose shape would make them, had they bulk and size,
More hideous foes than fancy can devise;
With helmet heads and dragon scales adorn'd,
The mighty myriads, now securely scorn'd,
Would mock the majesty of man's high birth,
Despise his bulwarks, and unpeople earth.[2]

In the winged or perfect state, hymenopterous insects generally occur on flowers, and they may be regarded as more abundant in southern than in northern regions. We shall not here dilate upon the generalities of the order, as it is our intention to notice all the more remarkable historical facts, in our sketch of the principal tribes and genera. We shall merely remark, that notwithstanding the numerous and always delightful observations of Réaumur, Degeer, Huber, Latreille, Walkenaer, and others, the hymenopterous order still presents a vast and fruitful field of discovery to the zealous cultivator of entomological science. Christus has combined in a special work[3] a great deal of excellent information; but his labours are imperfect in relation to the present condition of the subject. The *Systema Piezatorum* of Fabricius is merely a descriptive catalogue of species, assembled together without any precise notion of sexual distinctions, not seldom inaccurate in the exposition of generic characters, and extremely incomplete in relation to the European species. Jurine has carefully distinguished the sexes, and his groups are an improvement on those of his predecessors. Lepelletier de St-Fargeau,[4] Serville, Klug,[5] and, last though not least,

directs itself towards the tip of the wing (fig. 3, *b*). This range is frequently divided into two, three, or four lesser cells, by means of intersecting nervures (fig. 4, *e*, and fig. 1, *e*). If two of these cells are much developed, and the second one, on the contrary, is so circumscribed that it cannot reach the margin of the radial nervure, we have then a peculiar character. The two developed cells, instead of being separated from each other by the entire interval of the second cell, are kept apart, for a space, only by a simple nervure, the length of which is proportional to the curtailment of the second cell; and in this way the latter has no other connection with the radial cell above it, than that it adheres to, or depends from it, as it were, by a kind of pedicle or stalk,—for which reason it is then named *petiolated* by Jurine (fig. 2, *b*). If it happens that the cubital nervure does not attain to the extreme margin of the wing, the spaces which it partly forms are regarded as *incomplete*.

It has been already stated that, besides the large nervures named cubitus and radius, Jurine has distinguished others, which also spring from the base of the wing, as at fig. 1, *g*. These produce others of a secondary kind, which mount towards the cubital cells, sometimes attaining to the first and second, sometimes to the second and third, and sometimes only to a single cell. These have received the name of recurrent nervures (fig. 1, *f*). By anastomosing among themselves, and with the cubitus, the brachial nervures and their branches form several cells, which Jurine has named the *humeral* (fig. 4, *h*, *h*, *h*, *h*, *h*). Of these Latreille distinguishes as *discoidal*, such as are situated in the centre of the wing (fig. 2, *i*, *i*). The recurrent nervures always concur in their formation. Among lepidopterous insects, the cell situated in the centre of the wing is prolonged uninterruptedly as far as the base.

Since we have entered into these details, we may here also mention briefly a few additional particulars, relating chiefly to the nomenclature of the outline of the wings. The *base* is that part which articulates with the thorax (fig. 1, *a*, *b*, *g*). The *point*, *summit*, or *anterior angle*, is that part which is most directly opposed to the base (fig. 1, *h*). The external, anterior, or upper margin of the wing extends from the base to the summit (fig. 1, *a*, *c*, *d*, *e*, *h*). The posterior, inner, or anal angle, is formed by the point of union of the posterior and inner margins (fig. 1, *i*). The posterior margin commences at the anterior angle or summit, and ends at the posterior or inner angle (fig. 1, *h*, *f*, *i*). The internal margin extends from the posterior angle to the base of the wing (fig. 1, *i*, *g*).

In addition to the works mentioned in a preceding note, see also the article AILES in the *Diction. Class. d'Hist. Nat.*; the article RADIALES in the *Encyclop. Méth.*; and M. Chabrier's elaborate *Essai sur le Vol des Insectes*.

[1] *Journal de Physique*, Sept. 1828.

[2] Cowper's *Retirement*.

[3] *Naturgeschichte, Klassification, und Nomenclatur, der Insecten vom Bienen, Vespen, und Ameisengescheleclit*, von J. L. Christ. Frankfort, 1791.

[4] In various articles and treatises in the *Encyclop. Méth.*

[5] *Monographia Siricum Germaniæ, atque Generum illis adnumeratorum, cum tab. æn. col.* Berlin, 1803; several memoirs regarding *Hymenoptera*, in the *Recueil* of the Society of Naturalists of Berlin; a critical review of the genera of Fabricius, derived from *Apis* of Linn. in Illiger's *Magazin für Insectenkunde*, &c.

Hymenoptera Terebrantia.

our own inestimable Kirby,[1] have published valuable though partial additions to our knowledge of the history and classification of the hymenopterous tribes.[2]

Latreille divides our present order into two primary sections.

TEREBRANTIA,[3]

In which the Females are provided with an Ovipositor.

FAMILY I.—SECURIFERA.[4]

Abdomen sessile, or united by the entire breadth of its base to the thorax, of which it appears a continuation, without distinct or separate power of movement. The females have an ovipositor (*tarière*), generally in the form of a saw, and which serves not merely for the deposition of the eggs, but also for the construction of a proper place for their reception. The larvæ have always six scaly feet, and frequently several others which are membranous. This family forms two tribes.

TRIBE 1ST, TENTHREDINETÆ, OR SAW-FLIES.

Of these the mandibles are lengthened and compressed. The ligula is divided into three, as if digitated. The ovipositor is composed of two plates, toothed like a saw, pointed, united, and lodged in a groove of the posterior extremity. The maxillary palpi are always composed of six articulations, and the labial of four. The latter are always the shorter. Both pairs of wings are divided into numerous cells. This tribe corresponds to the great genus TENTHREDO of Linnæus.

The abdomen of these insects is cylindrical, rounded posteriorly, composed of nine segments, and so united to the thorax as to appear almost like a uniform continuation of that part. The wings appear as if rumpled, and there are two little grain-like coloured bodies behind the scutellum. The form and composition of the antennæ vary. The mandibles are strong and toothed. The extremity of the maxillæ is almost membranous, or at least of a less coriaceous consistence than the base. The palpi are filiform, or nearly setaceous, and composed of six articulations. The ligula is straight, rounded, divided into three parts, of which the central is the narrowest; its sheath is usually short. The abdomen of the female is provided at its lower extremity with a double moveable ovipositor, scaly, serrated, pointed, and enclosed within two other concave plates, which serve it as a sheath. It is by the action of the teeth of this instrument that the insect perforates the stalks and other parts of plants, in which she lays her eggs. These she afterwards imbues with a peculiar frothy liquor, which seems to prevent the parts of the plant from reuniting, and even causes the formation of a concave chamber, or of ligneous parts resembling galls, in which the excluded larvæ dwell, either in a state of solitude, or in company, according to their kind. After undergoing its final metamorphosis, the perfect insect makes its escape by gnawing a circular overture. The larvæ of many species, however, live exposed upon the foliage of trees and plants. They bear a great resemblance to caterpillars in their general form and colouring, but they present either from eighteen to twenty-two feet, or only six; whereas in caterpillars properly so called, these parts range merely from ten to sixteen. They frequently continue in the larva state for several months, or throughout the winter, and remain but a short time in the nympha state, previous to the assumption of which they spin a cocoon. We shall briefly notice the principal genera into which these insects are now divided.[5]

In CIMBEX of Olivier and Fab. (Plate CCXLIV. fig. 1) the antennæ are alike in both sexes, and terminate in a button-like expansion. The larvæ have twenty-four feet, and some of them when tormented will spout out a greenish liquid to the distance of a foot. In HYLOTOMA, Lat. (ibid. fig. 2), the antennæ exhibit only three distinct articulations, of which the last is in the form of an elongated prismatic or cylindrical club, more slender, ciliated, and sometimes forked in the males. A well-known species (figured as above), the *Tenthredo rosæ* of Linn. belongs to this genus. In the genus TENTHREDO properly so called (ibid. fig. 3), the antennæ are composed of nine articulations, which are simple in both sexes. The larvæ have from eighteen to twenty-two feet. In the perfect insects the number of teeth of the mandibles varies from two to four. The amount of radial and cubital cells of the wings also varies in different species. Hence the formation of the genera *Allantus, Dolerus, Nematus,* &c. by Jurine, Leach, and other naturalists. The genus CLADIUS of Klug has also nine joints in the antennæ, but those parts are pectinated on one side in the males. In ATHALIA of Leach the body is short and thick, as in Hylotoma, but the antennæ, simple in both sexes, have from ten to fourteen articulations. The genus *Pterygophorus* of Klug are remarkable for their antennæ, composed at least of sixteen articulations, being pectinated or fan-shaped in the males, and serrated in the females. In LOPHYRUS of Lat. (Plate CCXLIV. fig. 4) the antennæ are doubly pectinated in the males, and resemble a triangular plume (fig. 5); they are shortly serrated in the females (fig. 6).[6] In all the preceding genera the labrum is quite apparent, and the four posterior tibiæ are either unfurnished on their inner side with spines, or exhibit only one. But in the following the labrum is concealed, or but slightly projecting, and the inner side of the four posterior tibiæ exhibits before its extremity two, and frequently three spines. Such are MEGALODONTES, Lat. in which the antennæ are serrated or pectinated, and PAMPHILUS of the same author, in which those organs are simple in both sexes.

The concluding Tenthredinetæ have the ovipositor prolonged beyond the groove, and projecting posteriorly. The antennæ are simple, and always composed of a great number of articulations. They constitute the genera XYELA, Dalm., CEPHAS, and XIPHYDRIA, Lat. Of the last named the antennæ are inserted near the mouth, and become attenuated towards the termination (Plate CCXLIV. fig. 7).

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[1] In his *Monographia Apum Angliæ*, " ouvrage," says Latreille, " qui a immortalisé son auteur."

[2] Consult also the article HYMENOPTERES in the *Diction. Class. d'Hist. Nat.* t. viii. pp. 458–62.

[3] From *terebro*, to bore or pierce.

[4] From *securifer*, a hatchet-bearer, in allusion to the wood-cutting instrument with which these insects are armed,—which, however, happens to be a saw.

[5] For the details, see Lepelletier de St Fargeau's *Monographia Tenthredinetarum Synonymia Extricata*; Klug's *Entomologische Monographien*; Leach's *Zoological Miscellany*, vol. iii.; and *Règne Animal*, t. v. p. 271, &c.

[6] *Lophyrus pini*, the species figured on the plate referred to, has become much more common of late years in Scotland, since the plantation and growth of larch forests.

TRIBE 2D, UROCERATA.[1]

The insects of this tribe are distinguished from those of the preceding by their mandibles, which are short and thick, by their ligula, which is entire, and by the ovipositor of the female, which is sometimes projecting and composed of three thread-like parts, sometimes spirally rolled within the abdomen, and of a capillary form. They compose the old genus SIREX of Linn.

The antennæ of these insects are filiform or setaceous, vibratory, and composed of from ten to twenty-five articulations. The head is rounded and nearly globular, the labrum very small, the maxillary palpi filiform, consisting of from three to five articulations, and the labial of three, of which the last is largest. The body is almost cylindrical. The anterior or posterior tarsi, and in several species the colour of the abdomen, differ according to the sexes. The females deposit their eggs in ancient trees, generally in those of the pine tribe. The ovipositor is lodged at the base of the abdomen, between two valves, which form a protecting groove.

In the genus ORYSSUS, Lat. (Plate CCXLIV. fig. 9), the antennæ are inserted near the mouth, the mandibles are without teeth, the maxillary palpi are long and five-articulate, the posterior extremity of the body is almost rounded and slightly prolonged, and the ovipositor is capillary and spirally rolled in the interior of the abdomen. There are only two species found in Europe, both of which are exceedingly active, and occur on trees in spring. We have figured *O. coronatus*, the sole British species. In SIREX properly so called (*Urocerus*, Geoff.), Plate CCXLIV. fig. 8, the antennæ, inserted near the front, consist of from thirteen to twenty-five articulations, the mandibles are toothed on their inner side, the maxillary palpi are very small, almost conical, of two articulations, and the extremity of the last segment of the abdomen is prolonged in the form of a tail. The ovipositor consists of three threads. These insects are of rather large size. They inhabit more particularly forests of pine and fir, in cold and mountainous countries, and during flight produce a buzzing noise, like that of an humble-bee. The larvæ have six feet, with the posterior extremity of the body terminating in a point. It lives in the interior of wood, where it spins a cocoon, and undergoes its metamorphosis. Our most noted species is the *S. gigas* of Linn. The male has a yellow abdomen, with a black extremity; the female is black, with a yellow spot behind each eye, and the second and three terminal rings of the abdomen also of the latter colour. Owing to the disparity of aspect of the sexes, they have been not unfrequently described by naturalists as distinct species.

FAMILY II.—PUPIVORA.[2]

The various groups which compose this family are distinguished by the abdomen being attached to the thorax by a simple portion of its transverse diameter, or even in many instances merely by a slender thread or pedicle, so that its mode of insertion is distinct and obvious, and admits of a separate movement. The larvæ are apodal, and for the most part parasitical and carnivorous. Latreille divides them into six tribes, as follows.

TRIBE 1ST, EVANIALES.

In these the wings are raised, and the upper at least are areolated. The antennæ are filiform or setaceous, and composed of from thirteen to fourteen articulations. The mandibles are dentated on the inner side. The maxillary palpi consist of six, and the labial of four articulations. The abdomen is implanted on the thorax,—in some, just beneath the scutellum. The ovipositor is usually projecting, and composed of three setæ.

The following are the principal genera: EVANIA, Fab. (*Sphex*, Linn.) Plate CCXLIV. figs. 10 and 13; PELECINUS, Lat., ibid. fig. 12; FŒNUS, Fab. (*Ichneumon*, Linn.) ibid. fig. 14; AULACUS, Jur. and PAXYLLOMA, Brébisson.

TRIBE 2D, ICHNEUMONIDES.

In these the wings are also veined, and the superior always exhibit on their disc closed or completed cells. The abdomen takes its rise between the two posterior legs. The antennæ are generally filiform or setaceous (very rarely clubbed), and composed of a great number of articulations. In the majority the mandibles have no tooth on the inner side, and terminate in a bifid point. The maxillary palpi, always apparent or projecting, have usually not more than five articulations. The ovipositor consists of three threads or setæ.

Such is a brief exposition of the technical characters of a tribe of insects which embraces almost the whole of the great genus ICHNEUMON of Linnæus, and of which the natural economy and habits are so remarkable that we shall here take leave to extend our observations on their history. Perhaps we could not better illustrate the complex nature of the modern science of Entomology than by stating, that what we must here pass over in the space of a few columns, and which, even in the publications of comparatively recent writers, does not form a very important or greatly enlarged feature, occupies, in a work to which we have lately devoted our attention, upwards of 2800 pages.[3]

The general term Ichneumonides comprehends an extensive series of insects, important on account of the purposes to which they are subservient in the economy of nature, and deriving considerable interest from the peculiar manner in which these purposes are effected. They differ from most of the other members of the class to which they belong, in their mode of providing for their young,—presenting this peculiarity, that they deposit their eggs in the living bodies of other insects. In a tribe of such extent, considerable variety of external appearance necessarily prevails; but a genuine Ichneumon may in general be known by its elongated form, attenuated, and in most cases petiolated abdomen, terminated frequently in a long fissile seta; and by its filiform, porrected, often recurved and annulated antennæ, to which a constant vibratory motion is imparted. The European species vary in size from a fraction of a line to fifteen lines; those of tropical countries, however, greatly exceed these dimensions, a few of them ranking even among the largest insects. Upwards of 1300 species have been described as natives of Europe, of which number a great many hundreds exist in Britain.[4] The frequency of their occurrence, and singular habits of life, which often force them unexpectedly on the notice of naturalists while engaged in the study of insect

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[1] From ουρα, *tail*, and κερας, *horn*.
[2] From *pupa*, and *voro*, to devour, in allusion to their destruction of other insects by depositing eggs in their bodies, which usually destroy the pupæ.
[3] We allude to the complete and careful *Ichneumonologia Europæa* of Professor Gravenhorst of Breslau, in three very thick volumes 8vo, 1829.
[4] In the *Systema Naturæ* (12th edition), Linnæus describes only seventy-seven species of Ichneumon.

transformations, have secured some degree of attention for this tribe, even from the earliest periods. The word Ichneumon occurs in the natural history of Aristotle, by whom it is applied to a species of Sphex. Ray appears to be the first who used it to designate the tribe of insects to which it has ever since been restricted. Little, however, was known regarding the structure or habits of these creatures till the time of Frisch, who subjected them to an anatomical examination, and described the parts of the mouth, and formation of the wings, with great accuracy and minuteness. He was the first who employed the form and relative position of the cells of the latter to assist in distinguishing genera. Much valuable information resulted from the observations and experiments of Réaumur, whose work may be referred to for many interesting details regarding the manners and habits of the Ichneumonides.[1] Degeer also contributed materially to elucidate their history, and proposed a new arrangement of the family, characterized by his usual accuracy of discrimination.

In the numerous works on Entomology which appeared during the latter half of the eighteenth century, our knowledge of these insects kept pace with the increased zeal manifested towards the study of natural history during that important period. Linnæus, Scopoli, Fabricius, Schrank, Panzer, and others of inferior name, applied themselves successfully to investigate their history—reducing the information derived from their predecessors to a more systematic form, and greatly increasing the amount of known species. In 1807 Jurine published his new method for the classification of Hymenoptera, already mentioned. The application of his principles to the Ichneumonides afforded less satisfactory results than in most of the other tribes. Like all systems founded on a partial view of organic structure, it led, in many instances, to the violation of natural order, by separating cognate species, and associating others having no positive affinity. But though Jurine failed to establish an efficient mode of arrangement, he rendered important service to subsequent inquirers, by describing minutely, and furnishing with a suitable terminology, the variously modified forms of the organs of flight, which are found to afford characters of considerable value for the discrimination of genera. Latreille at different times published arrangements of this tribe, and by the number of his sectional divisions, generally founded on obvious characters, greatly facilitated the identifying of species.[2] But the amount of these had increased to such an extent, and they were found to approximate so closely to each other in external characters, that a comprehensive division, and a more detailed description of specific difference, became indispensable. This desideratum has recently been supplied by the publication of an extensive and elaborate work on the Ichneumonides by Professor Gravenhorst; an individual eminently qualified to unravel the complexities of this difficult tribe. An extensive intercourse with men of science enabled him to amass a large collection of these insects from all parts of Europe; while habits of minute observation and patient research, combined with just views of systematic arrangement, and an accurate perception of the affinities of consecutive groups, qualified him to employ to the best advantage the ample materials thus obtained. The result of his labours appeared in 1829, as specified in a note on our preceding page. The arrangement adopted is fundamentally the same as that previously published by himself and Nees ab Esenbeck.[3]

The body of the Ichneumons is more or less elongated, and in most instances naked and shining, seldom rough or impressed with punctures. It is occasionally covered, particularly on the head and thorax, with a pubescence composed of slender erect hairs, or it is somewhat sericeous and opaque, with a soft decumbent pubescence. The prevailing colours are rufous, black, and yellow, variously intermingled with lines and patches of white. In the great majority of species, there are one or two spots of the latter colour on the thorax, at the insertion of the wings. The scutellum is most frequently white. The feet are very often of a reddish colour, at times red and black; but they are never entirely black, the anterior femora being always pale on the under side. The head is prominent, generally orbiculate or subovate anteriorly, in many instances a little narrowed towards the neck, and nearly of the same breadth as the thorax. The forehead is sometimes armed with one or two short erect horns, placed between the antennæ and stemmata. The latter are three in number, and disposed in a triangular form. The antennæ in the greater number of species are shorter than the body; in a few they are of the same length, very rarely longer, porrected, generally curved or involuted after death, especially in the females, filiform or setaceous, sometimes slightly compressed at the middle, as in some species of *Phygadeuon*, distinctly compressed in the *Barycerotes*, much compressed and dilated in the *Eucerotes*, and clavate in the *Hellwigiæ*. They consist of from eighteen to sixty articulations, of which the first or radicle is small, globose, and sunk in the head; the second or scape sub-cylindrical or sub-clavate, rarely ovate, very rarely sub-globose, always thicker than the rest (except in the antennæ of the *Barycerotes* and the *Eucerotes*), and longer than the two following; the third and fourth very short, rather stout, and often so closely united that they may be regarded as one joint; the fourth always shorter than the third, which is at times very inconspicuous; the fifth long, cylindrical; the remainder gradually decreasing in length, so that the apical joints often appear transverse. Such is the general appearance of the antennæ; but they are liable to numerous modifications. The mandibles are corneous, more or less arcuate, generally broadest at the base, and narrowed towards the apex; in a few instances they are straight, and in others linear, or even dilated at the extremity, where they are furnished with two teeth, except in a very few species, which have the apex entire or tridentate. The maxillæ consist of two parts, of which the basal portion, or stipes as it has been called, is usually of a corneous consistence and somewhat lanceolate form; the other portion (mala) is of a membranaceous substance, and bifid or bipartite. The palpi are four in number, elongate, filiform, and unequal; the maxillary are rather long, and consist of five joints, very rarely of four. They have been described by Fabricius and Panzer as having six joints. The third joint is generally the longest; the first, second, and fourth, very short; sometimes, however, one or other of these, or the fifth, is longest, and in a very few cases the third is shortest; in some species all the articulations are of equal length. The labial palpi are rather short, and consist of five joints, very rarely of three.

The Ichneumonides, like the rest of the Hymenoptera, are provided with four wings, composed of thin membrane, and of corneous ribs. These ribs are generally denominated nerves or nervures; and the various spaces into which the wing is divided by their intersection are called

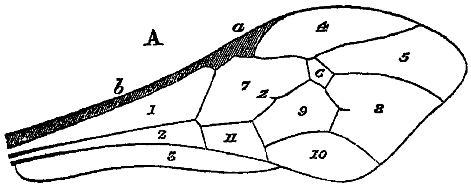
[1] *Mémoires*, tome ii. iv. et vi.

[2] *Histoire Naturelle, générale et particulière, des Crustacés et des Insectes*, tom. iii. et xiii.; see also *Règne Animal*, t. v. p. 281.

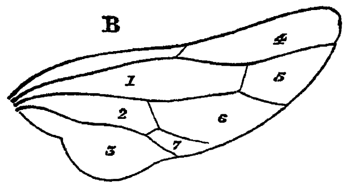
[3] The arrangement alluded to appeared in 1818, in the 9th volume of *Novorum Actorum Academiæ Naturæ Curiosorum*.

cells or areolets. The base of the wing (*radix*), or that portion of it which is inserted into the thorax, is of a substance intermediate between corneous and membranaceous, and is always more or less coloured. It is partially covered with a hard convex scale (*squamula*), which, however, may more properly be regarded as an appendage of the thorax. The anterior wings (fig. A) are longer than the posterior, narrow throughout a considerable portion of their length, and gradually dilated towards the extremity. The *stigma* (*a*) is distinctly marked, and varies

A



B



much in size. The thick rib of the anterior margin, extending between the stigma and the dorsal angle of the wing, is called the *radius* (*b*). By the anastomosing of the nerves, ten or eleven cells are formed, of which the three at the base of the wing are named humeral (*humerales*), 1, 2, 3; one radial (*radialis*), 4; two or three cubital (*cubitales*), 5, 6, 7; two lying under these discoidal (*discoidales*), 8, 9; and two towards the margin posterior (*posticæ*), 10, 11. When the cells are viewed in relation to the breadth of the wing, the three situate at the apex or posterior margin are said to be external (5, 8, 10); those next the humeral cells internal (7, 11); and those between the external and internal cells intermediate (6, 9). Of the humeral cells, that which lies next the radius is named the external (1), that next the margin the internal (3), and that which lies between these two the intermediate (2). The intermediate cubital cell (6) is generally denominated the areolet, and is important on account of the distinctive characters it affords. The interior cubital cell (7) is very large, in consequence of the nerve which ought to divide it into two parts, at least which does so in the other Hymenoptera, having become obsolete. In many species, however, a portion of this nerve is visible (*z*); and in some instances it extends nearly to the centre of the cell; but it is usually very short, or a projecting angle alone indicates the point whence it ought to issue; and in the less typical species all traces of it are obliterated. The areolet likewise is occasionally awanting; different individuals of the same species have it or have it not; and examples occur in which it is distinctly formed in one wing and awanting in the other. In general, however, it is present, and may readily be distinguished from the other cells by its inferior size and angular form. It is either five-angled or quadrangular, triangular or orbiculate. But all these forms are liable to numerous modifications, and one passes into another. The posterior wings (B) are shorter and narrower than the anterior, and nearly of equal breadth throughout. By the anastomosing of the nerves, seven cells are formed, of which the three at the base of the wing are named internal (1, 2, 3), and four at the posterior margin external (4, 5, 6, 7). In the sub-genus *Pezomachus* the wings are generally absent, and when present are extremely imperfect, and usually unfit for the purposes of flight, although their structure, as far as it can be traced, exactly corresponds to that of the more perfect species. The abdomen, which is very variable in form, is composed of seven or eight segments, the eighth being more or less concealed, and often entirely obsolete. This imperfect development of some of the segments has led authors to give various accounts of their number. In addition to the seven usually enumerated, Audouin is of opinion that there is another of very small size, which unites the abdomen to the thorax. According to Blainville, there are never fewer than ten segments, of which the two at the apex are always concealed. The first or basal segment bears on each side of it a small tubercle, more or less distinct, which forms the outlet to a spiracle. When the tubercles are placed very near the base, and the anterior part of the basal segment is not much narrower than the following segments, and these nearly correspond to the breadth of the thorax, the abdomen is said to be sessile; the posterior part of the first segment being so short that it can with difficulty be distinguished, and the anterior part consequently appearing to adhere immediately to the thorax. If this segment, or the posterior part of it, be gradually contracted towards the base, the abdomen is said to be sub-sessile or sub-petiolate. When the posterior part is narrow and elongated, linear or filiform, that part is called the petiole or footstalk, and the abdomen is said to be petiolate.

The sexes of these insects can with difficulty be distinguished,—few species affording any permanent external marks of sexual difference. The males in some instances differ from the females in having a more slender abdomen, in others the antennæ are thicker, and in some species they are more slender than in the females. Many of the latter are distinguished by having a white ring round the antennæ,[1] which after death become curved or spirally convoluted. The males may frequently be known by having the colours with which they are adorned clearer and more distinctly defined than in the opposite sex. But the most certain, and often the most obvious mark of sexual distinction, is the ovipositor with which the females are provided. This remarkable appendage varies in its form, in fine accordance with the varied economy of different species. Some Ichneumons deposit their eggs on the bodies of caterpillars; an operation which they accomplish by merely piercing the skin. Others, in order to lodge their eggs in a proper receptacle, are obliged to perforate the nests of insects, and to penetrate to the bottom of crevices too narrow to admit of the whole body. The former are furnished with a short, retractile ovipositor, seldom exserted, and lodged in a groove on the under side of the abdomen. But the ovipositor of the latter is often of considerable length, exceeding in some instances that of the whole body. It is composed of three parts; that in the centre is a slender flexile seta, of a corneous substance, very smooth and shining, generally straight and rounded, rarely arcuate and compressed, and most commonly of a rufous or castaneous colour. It is provided with a longitudinal central canal, through which the eggs are propelled. The apex is often compressed and dilated, and impressed with transverse inequalities; it is frequently compressed throughout its whole length, and occasion-

[1] In regard, however, to this distinctive character between the sexes, Gravenhorst observes in his preface (page 10)—"nonnullarum mares quoque hoc ornamento gaudent."

ally bent upwards at the extremity. On each side of this central seta is placed another, adapted, by the concavity of the inner surface, to enclose it as in a sheath. These lateral appendages are generally punctate and pubescent externally, and somewhat incrassate towards the apex. They issue from the terminal segment of the abdomen; but the central tube or oviduct originates in the interior, and must necessarily be connected with the viscera, to whose contents it forms the outlet.

When a female Ichneumon, furnished with an apparatus of the kind just described, has discovered the retreat of a larva or pupa, in which she wishes to deposit her eggs, she stations herself immediately over the spot, and raising her abdomen to a vertical position, bends the ovipositor under her belly, and thrusts it into the aperture. This operation is much facilitated by the great flexibility of the instrument, and the ease with which it can be accommodated to any circumstances in which it requires to be employed. It penetrates to a considerable depth into the body of the larva, lest the eggs, by being placed near the surface, should be thrown off when the skin is changed. Upon their exclusion from the egg, the parasitical young make their way still farther into the interior of the larva, consuming the fat that surrounds the muscles and viscera, but carefully abstaining from doing injury to the vital organs. In this state they are gregarious, and were found by Réaumur (who has given a figure of a caterpillar so infested) to be arranged in regular rows in the interior of the caterpillar. When they have arrived at maturity, they undergo their destined change either in the body of the larva which served them as a matrix, or, gnawing a passage through its skin, they construct externally their silk cocoons, and are then converted into pupæ, from which, after a longer or shorter period, they emerge in their declared or perfect form.

A still more remarkable method of rearing its offspring is adopted by the *Ophion luteus*, and probably by all the other species belonging to that genus.[1] The eggs of this insect are deposited on the caterpillar of the Puss Moth (*Cerura vinula*), to which they firmly adhere by means of an elongated pedicle or foot-stalk. When the larvæ are evolved, they do not enter the body of the caterpillar, but remain attached to the columnar appendage, through which they extract, by suction, the juices necessary for their sustenance. The caterpillar dies before it assumes the pupa state, but this event in no case proves fatal to the larvæ, as it either does not occur till they require no further nourishment, or they avail themselves of that principle of accommodation to existing circumstances, which insects possess in such a remarkable degree, and undergo their destined changes as soon as their supply of food begins to be withdrawn.

Ichneumons are generally active and rapid in their motions; many of them, particularly those belonging to the genera *Ichneumon* proper, and *Cryptus*, continually vibrate their antennæ, a circumstance which induced the older writers to call them *Muscæ vibratoriæ;* others, such as the *Ophiones*, are of slower habits, and have not been observed to exhibit this peculiarity in the movements of their antennæ. The larger species fly with considerable celerity, and cannot very readily be approached, unless when engaged in depositing their eggs; an operation with which they are so entirely engrossed, that all regard for their own safety appears to abandon them. They occur in flowers, on the trunks of trees, and on plants; also on walls and in houses; but their favourite places of resort are the flowers of umbelliferous plants. The species furnished with a long ovipositor usually frequent walls and the trunks of trees, for it is in these situations that they find the larvæ on which a singular instinct leads them to deposit their eggs.

Our knowledge is obscure regarding the food of these insects in the perfect state; but it appears to be derived from the vegetable rather than the animal kingdom. We kept one alive, however, during the greater part of a winter on calf-foot jelly. They have often been observed to examine carefully with their mouths the pollen of plants; and it is probable that the pollen, or rather the honey, of flowers, affords them nourishment. Indeed it is expressly affirmed by Fabricius, that it is this material which forms their food. They do not seem to attack or devour other insects, or larvæ, or spiders, but associate with them without offering the least annoyance. It is likely, therefore, that those authors who assert that they are of predatory habits, mistook for Ichneumons certain species of an allied group (*Spheges*), to which they bear resemblance. Whenever they attack a larvæ, it is not for the purpose of employing it as food, but to convert it into a matrix for the reception of their young. But, though they do not devour spiders, as has been asserted, that insidious tribe of creatures is by no means exempted from their destructive visits,—for they oviposit either on the spiders' eggs, or on the dense silky web in which these are frequently enveloped; and the larvæ when excluded consume the substance of the eggs, and are then changed into nymphs and perfect insects within that silken chamber, so carefully constructed for a far different purpose.

The larvæ of the Ichneumonides are without feet. The tissue of their cocoons is of fine silk, usually of a beautiful yellow, or pure white, according to the species. Some, however, are banded with brown and yellow. We have already stated that their positions are various. A remarkable instance is occasionally met with of a *suspended* cocoon. It hangs to the leaves or twigs of the oak-tree, fastened at one extremity by a silken cord. This cocoon is farther remarkable for the manner in which it executes little springs, several inches in height. These are no doubt occasioned by the enclosed larva, which probably has space enough within to admit of its body being bent and retorted, after the fashion of the little worms which we sometimes see vaulting within the hollow walls of an old cheese.

Several Ichneumons are apterous. These Linnæus placed with the Mutillæ. Degeer describes one which proceeded from a ligneous gall which he found upon the stalk of a species of Potentilla. It first attracted his notice by two inflated conical pieces, pointed at the end, attached to the upper and posterior portion of the thorax, and directed backwards. They were moveable at the base, and the insect worked them about in all directions while itself in motion. It was extremely small, and leapt with great activity. As its hinder thighs were not enlarged, Degeer inferred that its springs were produced by curving its abdomen, and then pressing that part forcibly against the plane of its position.

In regard to the situations most favourable for collecting Ichneumonides, we may observe, that wherever other insects, especially in the larva state, abound, there also we may expect to find multitudes of these parasitical depredators. Having so greatly extended our general observations on this interesting tribe, our limits will less easily admit of our entering into descriptive details of genera and species. For these the reader must consult the works to which we have alluded. We shall however

[1] Degeer, ii. p. 850, pl. xxix. fig. 15.

enumerate the genera adopted by Latreille. They are as follows: STEPHANUS, Jur. (Plate CCXLIV. fig. 15 and 16); XORIDES, Lat.; PIMPLA (ibid. fig. 19); CRYPTUS, OPHION, and BANCHUS, Fab., Helw.; JOPPA, Fab. (ibid. fig. 21); ICHNEUMON proper (ibid. fig. 17); ALOMYA, Fab.; PELTASTES, Illiger (ibid. fig. 18); ACÆNITUS and AGATHIS, Lat.; BRACON, Jur.; MICROGASTER, Lat.; HELCON, Nees d'Es.; SIGALPHUS, Lat.; CHELONUS, Jur.; ALYSIA, Lat.[1]

We shall now exhibit a few examples of Gravenhorst's systematic exposition of the Ichneumonides, and these we shall select from British species.

GENUS ICHNEUMON, Grav. Abdomen petiolate, convex; head transverse; scutellum flat or convex; areolet in most instances pentagonal; (ovipositor concealed or sub-exserted).

This genus includes a great many sub-genera, of which we shall choose the first, or that which bears the same name as its principal, viz.

Sub-genus Ichneumon. Abdomen oblong or sub-ovate; the first segment globose, rough, the petiole long, linear, arcuate; areolet pentagonal; antennæ and feet of moderate or medium size; (ovipositor concealed or sub-exserted).

Section 7th of Gravenhorst.

Scutellum pale; the abdomen either with pale markings, or some of the segments entirely yellow, the apical segment black.

I. *luctatorius*, Fab. Linn. Lat. Grav. Length of the male from five to nine, of the female from five to seven and a half lines. The head of the male, with the mouth and face, yellow; of the female, either entirely black, or, with the interior orbits of the eyes, a lateral spot on the clypeus, the palpi and mandibles, yellow, the apex of the latter fuscous. Antennæ of the male porrect, setaceous, half the length of the body, or a little longer, the first joint yellow beneath; those of the female half the length of the body, curved at the tip, from the ninth to the thirteenth, or from the twelfth to the fourteenth joints, white above, the basal joint sometimes ferruginous beneath. Thorax gibbous; with a yellow line or spot before the wings, and another beneath them, one of which is occasionally awanting; the anterior line, in the female, ascending as far as the neck, of which the upper margin, in the male, is at times yellow; the male has sometimes a yellow spot beneath the scutellum. Scutellum yellow. Wings of moderate size, or rather ample, silaceo-hyaline; the stigma fulvous or ferruginous, rarely fuscescent, the radius fuscous or ferruginous; the radix yellow or ferruginous, rarely fuscous; the squamula either yellow or fuscous, with a whitish or rufescent spot; the areolet pentagonal. The feet of moderate size; the anterior femora on the under side, and for the most part at the apex also, yellow, black towards the base, and sometimes entirely black: the intermediate femora, with the apex, sometimes as far as the middle, and in a few cases the whole under surface, yellow; tibiæ yellow, the posterior black or fuscous at the apex; tarsi yellow, or flavo-ferruginous, the posterior with the tips of the joints sometimes blackish. Abdomen of the male elongated, longer sometimes by one half than the head and thorax, of the same breadth or a little narrower than the thorax, from the second to the third segments nearly of equal breadth, the following gradually narrowed towards the extremity; that of the female oblongo-ovate, a little longer than the head and thorax, and of the same breadth, the apex acute; the second and third segments yellow, in some females mixed with ferruginous and the margins fuscescent; the second segment of the males occasionally with a lateral abbreviated fuscous line, the third with a transverse line or two fuscous spots at the base; the fourth generally with a fulvous or rufous spot in the angles at the base, and more rarely the outer margin, or the base, or a lateral mark, rufescent or yellowish; the fifth very rarely with the outer margin yellowish.

The males of this species occur in considerable profusion in Britain, and throughout the greater part of Europe; the females are very rare.[2] They frequent sides of fields, and open places in woods, and are often to be found on umbelliferous plants during the autumnal months. They are liable to great variation both in size and colouring. Roxburghshire, and near Edinburgh, in considerable plenty.

GENUS TRYPHON, Grav. Abdomen convex, petiolate, or sub-sessile; head transverse; scutellum flat or convex; areolet triangular, or irregular, or absent; (ovipositor concealed, or sub-exserted).

Sub-genus Tryphon. Abdomen oblong, sub-sessile, or sub-petiolate; antennæ slender or middle-sized; feet of moderate length.

Section 4th of Gravenhorst.

Scutellum black, abdomen either entirely rufous, or rufous and black, or yellow and black.

T. *elongator*, Grav. Fab. Length from two and a half to five lines. The mouth generally rufescent, the apex of the mandibles black, or entirely black. The forehead with an erect horn, variable in length, but never exceeding that of the basal joint of the antennæ. Antennæ setaceous, shorter than the body; the first joint black, very rarely ferruginous beneath; the following generally fulvous or ferruginous, fuscous above, sometimes entirely fulvous or ferruginous. Thorax gibbous. Wings most commonly yellow-hyaline; the stigma and radius ferruginous, or pitchy straw-coloured, the radix straw-coloured, the squamula either black or pale ferruginous; areolet irregular or sub-triangular, sub-petiolate or sessile. Feet rather stout, the coxæ and trochanters black; the anterior femora yellow or testaceous, black externally towards the base; the intermediate femora black, with the apex yellow or testaceous, sometimes almost entirely testaceous on the under side; the posterior femora entirely black; the tibiæ yellow, rarely testaceous, the hinder with the apex and base black; the tarsi rufous or rufo-ferruginous, claws fuscous. Abdomen sub-petiolate, generally longer than the head and thorax, and nearly of the same breadth, sub-clavate, or sub-ovate, or fusiform; first segment canaliculate, gradually dilated towards the apex, about one half longer than broad, generally black, with the margin ru-

[1] For their characters, see *Règne Animal*, t. v. pp. 285–90.

[2] It is probable that the predominance in number of one sex over the other, so often alluded to by authors as an anomalous fact in the history of Ichneumons, is more apparent than real, and arises, in some instances, from the distinctive marks of sex being so slight as to elude observation, while in others the sexes are so dissimilar that each of them is received as a different species. The determination of the sexes is impeded by the difficulty of observing their intercourse. "Nunquam mihi successit," says Gravenhorst, "par copula junctum aut copulam parans invenire, licet forsan centum millia individua viva Ichneumonidum, in statu eorum libero naturali, viderim, et per triginta annos omnem operam dederim ut copulam viderem." (Vol. i. page 98.)

fous or fulvous, sometimes almost entirely rufous or fulvous, with the base black; the second, third, and fourth segments, sometimes also the base of the fifth, yellow or fulvous. Ovipositor very short, black, generally concealed.

This species abounds in most parts of Europe. It is plentiful in England, and is not unfrequent in Roxburghshire and other southern counties of Scotland. It likewise occurs near Edinburgh.

Genus Alomya, Grav. Abdomen petiolate, convex; head globose; areolet triangular.

A. *ovator*, Grav.; *Ich. ovator*, Fab. Lat.; *Ich. elongator*, Gmel. Oliv. Length from five and a half to seven and a half lines. Head sub-globose, somewhat quadrate when viewed from above, with the angles obtuse, sub-transverse; the face sometimes with a slightly elevated tubercle. Antennæ of the male setaceous, shorter than the body, or nearly of the same length, porrect, entirely black; those of the female moniliform, not half the length of the body, incurved at the apex, from the third to the thirteenth or fourteenth joints, ferruginous or testaceous, gradually becoming paler. Thorax very slightly gibbous. Scutellum triangular, flat. Wings of moderate size, hyaline or smoky-hyaline, the stigma ferruginous or fulvous, the radius piceous, the radix piceous or fuscous or ferruginous, the squamula black or fuscous; areolet pentagonal. The feet of the male with the coxæ and trochanters black; the femora of the fore legs ferruginous or fulvous, generally with the apex sub-testaceous and the base black; those of the middle legs generally black, with the apex ferruginous; those of the hind legs entirely black; the tibiæ yellow or testaceous, the hinder occasionally with the apex fuscous; the tarsi testaceo-ferruginous. The legs of the female are shorter and thicker than in the male, the coxæ, trochanters, and femora black, the latter, in the fore legs, for the most part almost entirely, or the apex only, rufous or ferruginous; the tibiæ either entirely ferrugino-testaceous, or testaceous with the apex ferruginous; tarsi fusco-ferruginous. Abdomen petiolate, convex, elongate; that of the male rather more than one half longer than the thorax, and nearly of the same breadth, the segments from the second to the sixth equally broad; the petiole linear and slender; the colour black and rufous, variously intermingled. Ovipositor concealed.

This species is of frequent occurrence both on the continent of Europe and in Britain. Gravenhorst is of opinion that *Alomya victor*, Curtis, *Ent. Brit.* 120, is a variety of this species.

Genus Cryptus, Grav. Abdomen petiolate, convex; head transverse; scutellum flat or convex; (ovipositor exserted.)

Sub-genus Pezomachus, from πεζομάχος, *a fighter on foot*, because the species, from the imperfect development of the organs of flight, are unable to attack larvæ on the wing. Body small; abdomen petiolate; wings awanting or very small; ovipositor exserted, short, or of ordinary length.

P. *Hopei*, Grav. *Supplementa Partis* ii. vol. i. p. 715. Length from two and a fourth to two and a half lines. Head black, palpi rufous. Antennæ slender, curved, rather more than half the length of the body; from the first to the fifth joint rufous, the sixth or the sixth and seventh fuscous, from the eighth to the eleventh white, rufous beneath, the remainder rufous, fuscous above. Thorax and scutellum rufous; metathorax with two very short obtuse spines. Wings shorter than the thorax. Feet somewhat slender, rufous; the apex of the hinder femora, and sometimes of the tibiæ, black, the base of the latter whitish. Abdomen scarcely longer than the head and thorax, and a little broader, oblong-ovate; the three basal segments rufous; the fourth, with the sides and sometimes the base, also rufous; the fifth and sixth black; the seventh white. Ovipositor rather more than half the length of the abdomen, the sheath black, the tube rufous.

This insect, hitherto found in Britain only, occurs not unfrequently in oak coppices in Roxburghshire, near Minto, Cavers, &c. It is named by Gravenhorst after a distinguished English collector, our honoured correspondent, the Rev. F. W. Hope, by whose effective practical researches the *Ichneumonologia* has been enriched by many new species.

Genus Pimpla, Grav. Abdomen convex, sessile; scutellum triangular or sub-orbicular; (ovipositor exserted).

Sub-genus Lissonota, from λισσὸς, *smooth*, and νῶτος, *the back*, in allusion to the smooth upper surface of the abdomen. The abdomen in most smooth, shining; the apical segments of the female entire on the under side; areolet either awanting or triangular; (ovipositor long).

Section 1st of Gravenhorst.

Scutellum and abdomen black; the latter sometimes with the apical margin of the segments castaneous.

L. *setosa*, Grav.; *Ich. setosus*, Oliv.; *Ich. immaculatus*, Gmel.? Length from seven to nine lines. Labrum sometimes obscurely ferruginous. Antennæ subfiliform, somewhat incurved and tapering towards the apex, half the length of the body, at times nearly of the same length. Thorax slightly gibbous. Wings of moderate size, smoky-hyaline, the stigma and radius nigro-fuscous, the radix piceo-fuscous or piceo-ferruginous, the squamula black or fusco-ferruginous; areolet sessile or sub-petiolate, triangular. Feet elongate, fulvous, the coxæ black, the posterior tarsi for the most part black or fuscous. Abdomen a little longer and narrower than the head and thorax, or of the same breadth, punctate; that of the male sub-cylindric, somewhat narrowed towards the apex; that of the female oblong or sub-cylindric; the margins of the segments elevated, shining; the first segment sub-canaliculate; the third sometimes fuscous. Ovipositor the length of the body; the tube black or fusco-castaneous, rarely fulvous.

This insect is pretty widely distributed over the north of Europe, and is found occasionally in England.

Sub-genus Pimpla. The segments for the most part transversely impressed, the intermediate ones broader than long, those at the apex having, in the females, a longitudinal groove or fissure on the under side; the areolet triangular; (ovipositor of moderate size, rarely long).

Section 6th of Gravenhorst.

Scutellum, thorax, and abdomen black; the latter sometimes with rufous bands; posterior coxæ black.

P. *examinator*, Grav.; *Cryptus examinator*, Fab.; *Ich. rufescens*, Gmel. Length of the male from one and two thirds to four and a half, of the female from two and a half to six lines. Palpi of the male whitish or yellowish, rarely piceous. Antennæ of the male either entirely black, or ferruginous on the under side towards the tip, with the first and second joints, or the first only, whitish. Thorax of the female, rarely that of the male also, with a whitish or straw-coloured line or spot, sometimes obsolete, before the wings. Wings smoky-hyaline; the stigma and radius black or fuscous, rarely piceous; the radix straw-coloured, in the females for the most part ferruginous or fuscous; the squamula of the male straw-coloured or fuscous, of the female ferruginous or fuscous, generally with a whitish spot, seldom entirely whitish; the areolet irregular, sessile or sub-sessile. Anterior feet rufous or ful-

vous, the coxæ and trochanters black, in the male sometimes yellow beneath, the tibiæ generally with a pale ring near the base; the posterior legs, with the coxæ, black, having very rarely a rufous mark, or the outer side entirely rufous; trochanters black, the apex in the male generally rufous; femora rufous or rufo-fulvous, the knees sometimes black, the whole outer side in some females black; tibiæ blackish, with a whitish ring near the base, in the male sometimes rufous near the apex; tarsi of the male black, of the female fuscous or fusco-ferruginous. Abdomen of the male longer, and rather narrower than the head and thorax, sub-cylindrical; that of the female a little longer than the head and thorax, sometimes twice the length of the thorax, and of the same breadth, sub-cylindrical or oblongo-ovate; the first segment scrobiculate at the base, the rest with their apical margins somewhat elevated, shining, and generally obsoletely castaneous, in the male sometimes ferruginous. Ovipositor half the length of the abdomen, or a little shorter.

This species usually deposits its eggs on the larva of some kind of moth, and specimens have been obtained from the pupa of *Tinea padella*, and *Bombyx fuliginosa*. It is not a scarce insect on the continent of Europe, and it occurs both in England and Scotland. Near Cavers, Roxburghshire, and in the vicinity of Edinburgh.

Sub-genus Ephialtes. Abdomen long, in most instances tuberculated; the anterior segments, and generally the intermediate ones also, longer than broad, those at the apex with a longitudinal groove on the under side in the females: areolet triangular: (ovipositor long).

E. *manifestator*, Grav.; *Ich. manifestator*, Linn. Length of the male from six to eleven, of the female from nine to fifteen lines. Palpi fuscous or ferruginous, the labrum sometimes obscurely ferruginous. Antennæ filiform, half the length of the body, or a little longer, porrected, often slightly curved at the tip. Thorax occasionally with a minute testaceous or ferruginous spot at the base of the wings. Wings of moderate size, more or less smoky-hyaline, the stigma more or less obscure; radius fuscous, radix and squamula ferruginous or straw-coloured, areolet somewhat regularly triangular, sessile or sub-petiolate. Feet somewhat slender and elongated, fulvous or rufous; the posterior tarsi and tibiæ, and sometimes the knees, fuscous, the tibiæ for the most part ferruginous towards the base, especially on the inner side. Abdomen more than one half, or three times longer than the head and thorax, of the same breadth as the thorax, or a little narrower, cylindrical, black, very rarely fuscous; the first segment canaliculate, the rest more shining, with an obsolete lateral tubercle and elevated margins, the length of the segments from the first to the fifth exceeding their breadth often by one half. Ovipositor longer than the body, rarely of the same length, the sheath somewhat pilose; the tube fuscous or rufo-castaneous, rarely black or straw-coloured, the apex sub-compressed, lanceolate, faintly impressed with transverse lines.

This insect, which is the largest of the European Ichneumonides, occurs not unfrequently in many parts of Europe. It is found in England; and in Scotland it has been observed in Roxburghshire, and near Edinburgh. "On the first of October," says Gravenhorst, "I observed many females of this species on the decaying trunk of a willow, about to deposit their eggs. They traversed with much assiduity the barkless trunk, which was perforated with numerous holes, inhabited no doubt by the larvæ of other insects; and so free were they from apprehension, that when I touched them with my finger they did not fly off, but only slightly averted their bodies. They searched out and examined the holes by means of their antennæ, which were vibrating incessantly, and exploring on all sides. When they had selected a hole, they stationed themselves with the four anterior legs over it, and raising the body as high as possible, and the abdomen perpendicularly, bent the ovipositor downward in such a manner that it passed under the belly and thorax, and entered the hole over which they stood. It not unfrequently happened, when the hole was sufficiently large, that the whole abdomen was inserted, and the head, feet, and thorax were the only parts of the insects which remained free. Frequently also a contest took place between two females for the possession of a hole; but they did not employ their mandibles on these occasions, their fighting consisting entirely of violent concussions of their bodies, and strokes of the feet, till the weaker party retreated. When a female had obtained full possession of a hole, no attack could displace her; but she retained her seat even though assailed by a more powerful antagonist."

Genus Metopius, Grav. Abdomen sessile, convex, rough; scutellum quadrangular, the apical angles acute; (ovipositor concealed).

M. *necatorius*, Grav.; *Peltastes necatorius*, Illiger, Curtis, *Brit. Ent.*; *Ichn. vespoides*, Panz. Lat. Length from five to seven lines. Face concave, the margins elevated, either entirely or the sides only yellow, sometimes with a broad black line or spot in the middle; palpi at times yellow or ferruginous. Antennæ filiform, a little shorter than the body, seldom entirely black, with the joints from the third to the fourteenth ferruginous beneath, gradually becoming more dusky; for the most part, however, all of them are ferruginous beneath, except the first, which is either entirely black or yellow on the under side. Thorax gibbous, clothed, especially on the sides, with a fine whitish down; a line before the wings, and another, or a spot, beneath them, yellow; sometimes also two spots on the back of the metathorax, and less frequently a lateral spot on the prothorax, and two small dorsal spots before the scutellum, of same colour. Scutellum seldom entirely black, the apical angles, and sometimes the whole apex, yellow. Wings of moderate size, smoky-hyaline, especially towards the radius, fulvo-hyaline towards the apex; stigma and radius ferruginous or fulvous; radix black, rarely testaceo-piceous; squamula black; areolet transversely triangular, somewhat irregular, sessile or sub-petiolate. Feet of moderate size, the posterior femora incrassate; coxæ black; trochanters generally black, with the apex yellow: the anterior femora usually black, with one of the sides more or less yellow or ferruginous; the middle femora sometimes with the apex only ferruginous, rarely black, with the base and apex yellow; the hinder femora generally yellow at the base, with the apex black, very rarely entirely black; the tibiæ yellow or ferruginous, the anterior rarely fuscescent on the outer side; the posterior with the apex more or less blackish, rarely black, with the inner side ferruginous: the tarsi flavo-ferruginous, or ferruginous, the posterior with the joints from the second to the fifth dusky. Abdomen twice the length of the thorax, scarcely narrower, cylindric, punctate; first segment very short, yellow, with the base, and sometimes a longitudinal line in the middle, black; the second with a yellow spot on both sides in the apical angle, sometimes obsolete; from the third to the fifth, and very rarely the sixth also, with the margins, yellow; the terminal segments occasionally somewhat blackish-blue.

This species appears to be pretty generally distributed. It is not unfrequent in England, where it has been observed to issue from the pupa of *Stauropus Fagi*. Mr Curtis conceives this insect to be one of the sexes of *M. dentatus*.

Genus Bassus, Grav. Abdomen sessile, depressed; the first segment flat, of equal breadth; the terminal segments in the female sometimes compressed.

Sub-genus Bassus. Areolet either absent or triangular; antennæ and feet of moderate size or slender; (ovipositor sub-exserted, sub-erect).

B. *flavolineatus*, Grav. Length three lines. The head with a facial spot, the palpi and mandibles yellow, the latter with the apex black. Antennæ porrect, rather longer than the body. Thorax with the suture before the wings, and the lateral one between the prothorax and metathorax, together with a transverse line beneath the scutellum, yellow. Scutellum with the apex yellow. Wings smoky-hyaline, iridescent, the stigma and radius black-fuscous, the radius and squamula yellow. Feet rufous; the fore legs yellowish beneath, the base of the coxæ black; the hind legs with the tarsi and tibiæ black, the latter white at the base. Abdomen slightly depressed, the length of the head and thorax, and a little narrower; the first segment of equal breadth, one half longer than broad; the remainder transverse. Ovipositor very short, sub-exserted.

This species has been taken in England by the Rev. F. W. Hope, near Netley.

Genus Banchus, Grav. Abdomen compressed or sub-compressed, sessile or sub-petiolate.

Sub-genus Banchus. Abdomen sessile, rarely sub-sessile; areolet sub-rhomboidal, the lower external nerve of the interior cell sub-arcuate. (Ovipositor concealed).

B. *falcator*, Grav.; *Ich. venator*, Fab.; *Ich. falcatorius*, Fab. Gmel. Oliv. Panzer. Length from five and three fourths to seven lines. Mouth ferruginous, mandibles black at the base and apex, the external orbits of the eyes, rarely the internal also, yellow or ferruginous. Antennæ half the length of the body, or a little longer, slender and incurved towards the apex, beneath rufous or ferruginous, rarely fusco-ferruginous. Thorax gibbous, generally with a short sub-testaceous line below the insertion of the wings. Scutellum tuberculate, rarely sub-acuminate, sometimes ferruginous, very rarely yellow. Wings middle sized, fulvo-hyaline or somewhat smoke coloured; the stigma, radius, radix, and squamula fulvous, rarely ferruginous, the latter sometimes with a fuscous spot. Feet elongate, fulvous, for the most part yellow beneath, the coxæ black, occasionally with a ferruginous mark; the hinder tibiæ black at the apex, the tarsi ferruginous or ferrugino-fuscous. Abdomen longer than the head and thorax; the first segment gradually a little narrowed towards the apex, nearly one half longer than broad; from the first to the fourth segment narrower than the thorax, the back fusiform, the belly compressed; from the fifth to the seventh angular, the back, sides, and belly compressed; the first segment seldom wholly black, the apex being generally brown or rufous or fulvous; the second seldom wholly rufous, or black with a dorsal rufous spot, but most commonly brown or rufous with the base black, or the base rufo-ferruginous, the apex fulvous-yellow; the third with the back either entirely rufous, or the base black or the apex yellow, but more commonly black, with the base and a point at the apex rufous; the fourth sometimes, rarely also the fifth, sixth, and seventh, with the apex of the back, rufous.

The female of this species differs considerably from the male, particularly in the markings of the head and thorax. Neither of the sexes is rare, as they have been taken abundantly both on the continent and in England.

Genus Ophion, Grav. Abdomen compressed or sub-compressed, petiolate; antennæ filiform.

Sub-genus Paniscus. Abdomen sub-petiolate compressed, the back carinate; areolet triangular; the feet and antennæ somewhat slender; (ovipositor short).

P. *testaceus.* Length of the male from three to nine, of the female from three and three fourths to eight lines. The mandibles black at the apex, the face sometimes yellowish; the eyes and ocelli, sometimes also the hinder part of the head, fuscous or black. The antennæ for the most part obscure or fuscescent at the tip; in the male rarely fuscous or blackish, the base testaceous-ferruginous. Thorax sometimes with longitudinal fuscescent lines on the back. Wings hyaline or somewhat yellow-hyaline; the stigma testaceous or straw-coloured, in the male sometimes fuscescent, the radius fuscous or testaceous, the radix and squamula testaceous; areolet irregular sub-sessile, generally semi-complete, the lower portion of the exterior nerve obsolete. Feet fulvous, rarely ferruginous in the male, the hinder tarsi at times of a paler hue. Abdomen longer, sometimes by one half, than the head and thorax, compressed, the apex in the male obtuse, in the female truncate; testaceous, often fuscescent towards the apex, or somewhat fusco-fulvous towards the base; the sixth, seventh, and apex of the fifth segment, very rarely black-fuscous; the first segment gradually dilated towards the apex, five or six times longer than broad, the anterior portion nearly one half longer than the petiole. Ovipositor the length of a fifth or sixth part of the abdomen, black, the tube castaneous or fuscous.

This insect is of frequent occurrence throughout the south of Scotland in the autumn. It is likewise plentiful in England, and on the continent. It deposits its eggs on the larvæ of various moths, and occasionally on those of the genus *Tenthredo.*

Sub-genus Ophion. Abdomen petiolate, compressed, the back carinate; areolet absent, the interior cell receiving the two recurrent nerves; feet and antennæ slender, long; (ovipositor scarcely sub-exserted).

O. *luteus*, Grav. Fab.; *Ich. luteus*, Linn. Lat. Length of the male from six to nine, of the female from four to nine lines. The head in most individuals entirely rufous, or the internal orbits of the eyes yellow; rarely yellow, with the mouth and face, excepting the internal orbits of the eyes, rufous; very rarely entirely yellow; mandibles black at the apex: eyes and stemmata fuscous or blackish. Antennæ either a little longer or a little shorter than the body. Thorax testaceous or rufous, very seldom rufo-ferruginous, the prothorax with two longitudinal pale lines. Scutellum for the most part pale, sometimes yellow. Wings hyaline or somewhat smoky-hyaline; the stigma, radius, radix, and squamula fulvous or testaceous, the upper exterior nerve of the interior cell very seldom incrassate towards the stigma; in most instances, however, the rudiment of the nerve dividing the interior cell is observable, and it is sometimes produced as far as the middle, rarely beyond the middle of the cell. Abdomen testaceous, seldom rufous, the belly generally fuscescent, sometimes also fuscescent or blackish towards the apex. Ovipositor scarcely sub-exserted, blackish.

This species is pretty generally distributed over the western parts of Europe, and occurs not unfrequently in England. The female deposits her eggs on the larvæ of *Cerura vinula, Noctua præcox,* and other moths. "Ils y sont fixés," says Latreille, "au moyen d'un pedicule long et delié. Les larves y vivent, ayant l'extrémité postérieure de leur corps engagée dans les pellicules des œufs d'où elle sont sorties, y croissent, sans empêcher la chenille de faires sa coque; mais elles finissent par la tuer, en consumant sa substance intérieure, se filent ensuite des coques, les unes auprès des autres. et en sortent sous la

forme d'ichneumons."[1] The larvæ of another species, *O. moderator*, Fab. destroy those of its ally *Pimpla strobitellæ*.

Genus Hellwigia. Abdomen petiolate, compressed; antennæ clavate.

H. *elegans*. Grav. Length from five to six lines. Head thick and closely punctate, with two deep irregular foveæ on the forehead, and a longitudinal groove between the antennæ; that of the male yellow, the occiput, foveæ, and apex of the mandibles black; that of the female black, the external orbits of the eyes yellow. Antennæ porrect, dilated at the apex a little more than half the length of the body, and composed of about thirty joints; in the male fulvous, yellowish on the under side towards the base, the first joint fuscous above; in the female rufous, the first three joints black. Thorax short, gibbous; two simple or hook-shaped spots before the neck, a short line under the anterior wings, two points or a single one under the posterior wings, a perpendicular line or point at the sides of the thorax, a point under the scutellum, a large semilunar spot on the metathorax, and another on each side of it, yellow: all these markings in the male are larger and more contiguous. Scutellum yellow. Wings middle-sized, hyaline, the stigma straw-coloured, the radius and nervures piceous or fuscous, the radix and squamula yellow. Feet middle-sized, sub-elongate; those of the male entirely yellow, the posterior tarsi rufescent towards the apex, the joints from the second to the fourth black at the base; the anterior feet of the female yellow, the coxæ black, with a small apical yellow spot, the trochanters black at the base; the hinder feet fulvous, the coxæ black, with a yellow spot, the trochanters yellow, the base black. Abdomen nearly one half longer than the head and thorax; the first segment flaggon-shaped, shining, very smooth, the anterior part scarcely longer than broad, shorter, and one half broader than the petiole; in the male the first segment black, the apex yellow, from the second to the fourth testaceous-rufous or yellow, with the base sub-rufescent, from the fifth to the seventh yellow, the fifth, and sometimes the sixth also, with the base, blackish at the side; in the female the first, fifth, sixth, and seventh segments black, with the margin yellow, the intermediate segments fulvous or rufous, with the margin for the most part yellow. Ovipositor scarcely sub-exserted, black.

The preceding examples will suffice to illustrate Gravenhorst's mode of treating the Ichneumonides. We shall now proceed to

Tribe 3d, Gallicolæ.[2]

These have only a single nervure on the lower wings; the upper pair offer a few areolets or cells, viz. two at the base—the brachial, of which the internal is usually incomplete or slightly marked,—one radial and triangular,—and two or three cubital,—of which the second, in such as have three, is always very small, and the third very large, triangular, and closed by the posterior margin of the wing. The antennæ are either of equal thickness, or increase towards the termination, but not club-shaped, and are composed of from thirteen to fifteen articulations, the number when different in the sexes being generally greater in the males. These insects form the old genus Cynips of Linnæus (Plate CCXLIV. fig. 20).

Their general form is humped or gibbous, with the head small, and the thorax thick and elevated. The abdomen is compressed, carinated, or cutting inferiorly, and truncated obliquely, or obtuse, at the extremity. It is furnished in the females with an ovipositor, which seems to consist of only a single piece, long and delicate, or capillary, spirally rolled at its base, and attached near the origin of the abdomen. It is minutely described by Réaumur[3] With this admirable instrument it deposits its eggs in the leaves and stems of various plants, and on these its punctures produce those peculiar excrescences known by the name of gallnuts, so useful when employed along with a solution of green vitriol, or sulphate of iron, in dyeing blacks. Some of these insects are apterous. "Une espèce," says Latreille, "dépose ses œufs dans la semence du figuier sauvage le plus précoce. Les Grecs modernes, suivant à cet égard une méthode que l'antiquité leur a transmise, enfilent plusieurs de ces fruits, et les placent sur les figuiers tardifs; les Cynips sortent chargés de poussière fécondante, s'introduisent dans l'œil des figues de ces derniers, en fécondent les graines et provoquent la maturité du fruit."[4] This is the process known abroad by the name of *caprification*.

The genera of this tribe are Ibalia and Figites, Lat. and Cynips proper (*Diplolepis* of Geoff.). Of the genus last named we have figured *C. rosæ*, its larvæ, and the gall in which the latter dwell (Plate CCXLIV. fig. 20, 22, 23, 26, 27, 28).

Tribe 4th, Chalcidiæ.

These do not differ very materially from the preceding, except in the antennæ, which, with the exception of *Eucharis*, are geniculate, and form, subsequent to the bend, an elongated or fusiform club, of which the first articulation is not unfrequently lodged in a groove. The palpi are extremely short. The radial cell is usually wanting, and there is never more than a single cubital cell, which is not closed. The antennæ have not more than twelve articulations. The modern genera are very numerous, though all related to the genus Chalcis of Fab. The species are extremely small, brilliantly ornamented with metallic colours. Many of them are leapers. The ovipositor is generally composed of three threads, like that of the Ichneumons, and is salient. The larvæ likewise resemble those of that tribe in being parasitical, and some of them are so minute as to be able to dwell at large in the interior of insect eggs, themselves scarcely visible to the naked eye.

We shall here mention only two genera of the tribe, of each of which we have figured an example. *Chalcis minuta* (Plate CCXLIV. fig. 25), synonymous with *Vespa minuta* of Linn., is extremely common on umbelliferous flowers. It is black, with yellow feet. Another species, *C. annulata*, Fab., inhabits the nest of the pasteboard wasp of South America (*V. nidulans*), and appears to have been mistaken by Réaumur for the female of that insect. Our other representative, *Leucospis dorsigera* (ibid. fig. 24), is black, with the abdomen almost as long again as the thorax, and marked with three bands and two spots of yellow. There is a transverse yellow line upon the scutellum, and two others of the same colour on the anterior portion of the thorax. The female deposits her eggs in the nests of mason-bees.[5]

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1 *Règne Animal*, t. v. p. 287.

2 We now resume the system of Latreille.

3 *Mém. sur les Insectes*, t. iii. p. 483, et seq.

4 *Règne Animal*, t. v. p. 292.

5 For the other genera and species, see, besides, *Règne Animal* (t. v. pp. 295–9), Latreille's *Genera Crust. et Insect.* t. iv.; Klug's *Entomologische Monographien*; Dalman's *Analecta Entomologica*, and the Monographs and Memoirs of the same author; Maximilian Spinola's *Mémoire sur les Diplolépaires*; Mr Westwood on *Parasitic Hymenoptera* (*Phil. Mag.* 3d series, No. 3); Mr Halliday's *Essay* on the same subject in *Entom. Mag.* No. 3; Mr Walker's *Monographia Chalcidum*, published in the initiatory numbers of the last-named periodical; and a similar *Monograph* by M. Boyer de Foscolombe, in the *Ann. des Sciences Nat.* for July 1832.

Hymenoptera Terebrantia.

Tribe 5th, Oxiuri, Lat.

This tribe resembles the preceding so far as concerns the want of nervures in the lower wings, but the abdomen of the female is terminated by a tubular and conical ovipositor, sometimes internal and exsertile, proceeding like a sting from the anal extremity, sometimes permanently external, and forming a kind of tail. The antennæ are composed of from ten to fifteen articulations, and are in some cases filiform or slightly enlarged towards the extremity, in others clubbed in the females. The maxillary palpi in several are long and pendant.

The minor genera which compose this tribe are all more or less related to the genus Bethylus of Fabricius and Latreille. The only example we have here adduced is that of *Diapria elegans* (Plate CCXLV. figure 1), an insect belonging to a genus in which the wings have no cells. The maxillary palpi are projecting, and the antennæ have fourteen joints in the male, and only twelve in the female.[1]

Tribe 6th, Chrysides, Lat.

This tribe agrees with the three preceding in the want of nervures in the lower wings; but the ovipositor of the female is formed by the terminal segments of the abdomen, which somewhat resemble in their construction the tubes of a telescope, and are terminated by a little sting.[2] The abdomen, which in the female seems to be composed of only three or four segments, is arched or plain beneath, and is capable of being applied against the chest,—in which attitude the insect assumes the form of a ball This tribe includes the old genus Chrysis of Linnæus, and is remarkable for the extreme richness and brilliant lustre displayed by the colouring of many species. In these respects they rival the gorgeous humming-birds, and are known under the name of gilded wasps,—the *guepes dorées* of our continental neighbours. They are lovers of the cheerful sunshine, and during the bright days of early summer may be seen moving about in a state of great vivacity, almost of agitation, on walls, old timber, and other objects exposed to the gladdening influence of heat and light. They are also found on flowers, " beautifying the beautiful," and adding to their gorgeous petals all that is wanting to complete the glory of the " lilies of the field,"—a burnished or metallic lustre.[3]

The body of these insects is covered by a very solid integument. Their antennæ are filiform, geniculate, vibratile, and composed of thirteen articulations in both sexes. The mandibles are arched, narrow, and pointed. The maxillary palpi are usually longer than the labial, filiform, and composed of five unequal articulations;—the labial consist of three. The ligula is for the most part emarginate. The thorax is semicylindrical, and exhibits several impressed and transverse lines. The abdomen in the greater number is semi-oval, truncated at the base, and appears at first sight as if attached to the thorax by its entire breadth. The terminal segment is frequently marked by large punctures, and terminates in dentations.

These beautiful creatures deposit their eggs in the nests of the solitary mason-bees, and in those of other Hymenoptera. Their larvæ sustain themselves by devouring the lawful inhabitants.

In some, such as the genus Parnopes, Lat. (Plate CCXLV. figure 2), the maxillæ and labrum are very long, and form a kind of false proboscis, bent underneath. The palpi are small and biarticulate. The example figured, *P. carnea*, deposits its eggs in the nest of *Bembex rostrata.* In Chrysis proper there is no false proboscis. The maxillary palpi are of medium size, or elongated, and composed of five articulations; the labial consist of three. Several analogous genera are recognised by naturalists, such as Hedychrum, Lat. (Plate CCXLV. figure 3), in which the maxillary palpi are much longer than the labial, the ligula emarginate, and the abdomen rounded and entire at the extremity.[4]

Hymenoptera Aculeata.

ACULEATA.[5]

This, the second primary section of the hymenopterous order, is distinguished from the preceding by the want of an ovipositor. That organ is represented by a sting composed of three parts, concealed and retractile. It is characteristic of the females, and likewise exists in those individuals (imperfect in a sexual point of view) commonly called neuters, which constitute so important a feature in the social union of the gregarious kinds. It is, however, wanting in several of the ant tribe,—in which case the insect defends itself by ejecting an acid liquid, elaborated and contained in special reservoirs.[6] Our present Hymenoptera have always simple antennæ, composed of a constant number of articulations, that is, thirteen in the males and twelve in the females. The palpi are usually filiform; those of the maxillæ, which are frequently the longer, have six articulations,—the labial only four. The mandibles of the males are smaller, and generally less toothed, than in the others. All the wings are veined. The abdomen, united to the thorax by a thread or pedicle, is composed of seven segments in the males, and of six in the females.

The larvæ in this family are never furnished with feet. Their food is supplied to them by females or neuters, and varies in its nature according to the different kinds. Latreille divides the section into four families.

FAMILY I.—HETEROGYNA.[7]

The species of this family consist of individuals which differ from each other not only in their sexual characters, but in the presence or absence of the wings, and in other particulars. In all, the antennæ are geniculate, and the ligula small, rounded and hollowed, or spoon-shaped.

Some live in society, and consist of three kinds of individuals, of which two, that is, the males and females, are winged, and the third or neuters are apterous. In the two latter kinds the antennæ gradually increase in thickness, and the length of the first articulation equals at least the third part of their total extent; the second is almost as long as the third, and has the form of a reversed cone. The labrum of the neuters is large and corneous, and falls perpendicularly beneath the mandibles. These Hymenoptera comprise the genus Formica of Linnæus.

As a separate treatise under the article Ant[8] has been already devoted in this work to the elucidation of the his-

[1] For the other genera, see *Règne Animal*, t. v. pp. 300–2; *Genera Crust. et Insect.* t. iv.; Dalman's *Analecta Entomol.*; and Jurine's *Hyménoptères.*

[2] The details are given by Degeer in his *Mém. sur les Insectes*, t. ii. p. 834, pl. 28.

[3] In as far as we are competent to judge, plants and the mammalia seldom seem to exhibit a metallic surface. But that glowing adornment is frequent among foreign birds, and the subjects of our present treatise.

[4] See a *Monograph of the Chrysides*, by Pelletier de St Fargeau, in the *Ann. des Sciences Nat.* t. vii. p. 115.

[5] From *aculeus*, a sting.

[6] *Journal de Physique*, September 1828.

[7] From ἑτερος, *other* or *different*, and γυνη, *female.*

[8] See vol. iii. p. 261.

Hymenoptera Aculeata.

tory and habits of these admirable insects, so long noted for their foresight and industry, we shall not occupy our remaining space by repetition, but shall proceed to a brief sketch of the classification of the species, as promised at the conclusion of the article just referred to. Latreille divides the genus Formica as follows:—

1*st*, The genus FORMICA properly so called. These want the sting; the antennæ are inserted near the front; the mandibles are triangular, dentated, and incisive; and the pedicle of the abdomen is never composed but of a single squama or knot.

Of the European species we may mention *F. rufa*, Lat., of which the workers measure about four lines in length, and are of a blackish colour, with a great part of the head, the thorax, and the knot, fulvous. The thorax is uneven. The stemmatic eyes are discernible. This species builds in woods, and forms a dome-like or sugar-loaf shaped habitation of considerable size, composed of earth and fragments of wood, &c. Formic acid is obtained chiefly from this insect. The winged individuals make their appearance in spring. (Plate CCXLV. figure 4.) *F. sanguinea*, Lat., resembles the preceding in its workers; but the colour is sanguine red, with an ashy-black abdomen. It likewise dwells in woods, and is one of the species named Amazons or *légionnaires* by M. Huber. *F. cunicularia*, Lat., has the head and abdomen of the workers black. Around the mouth, the under parts of the head, the first joint of the antennæ, the thorax, and feet, pale fulvous. The worker of *F. fusca*, Linn., is of an ashy-black, shining, with the base of the antennæ and the feet reddish. The squama or knot is large, almost triangular, and there is an appearance of three stemmatic eyes. Both these species are attacked by the Amazons, carried off, and enslaved.

2*d*, The genus POLYERGUS, Lat. In these the sting is likewise wanting; but the antennæ are inserted near the mouth, and the mandibles are narrow, arcuated, or strongly hooked. In this genus is placed the *F. roussatre* of Lat. so common in France. It is this species which is more particularly named Amazon by M. Huber the younger.

3*d*, The genus PONERA, Lat. In these the workers and the females are armed with a sting. The pedicle of the abdomen is formed of a single scale or knot; the antennæ of the individuals just mentioned are thickened towards the extremity; the mandibles are triangular, and the head is also nearly of that form, without remarkable emargination at its posterior extremity. *F. contracta* of Lat., which occurs near Paris, belongs to this division. The worker seems scarcely provided with eyes, and lives under stones in not very numerous groups. It is very small, black, nearly cylindrical, with the antennæ and feet of a yellowish brown.

4*th*, The genus MYRMICA, Lat. In these there is also a sting; but the pedicle of the abdomen is formed of two knots. The antennæ are exposed, the maxillary palpi are long, with six distinct articulations, and the mandibles are triangular. Such is the *fourmis rouge* of Latreille, of which the worker is reddish, finely chagrined, with the abdomen smooth and shining. There is a spine upon the first knot of the pedicle, and the third segment is brownish. This species occurs in woods, and bites sharply.

5*th*, The genus ATTA of Fabricius, which scarcely differs from Myrmica, except by its very short palpi, of which the maxillary are composed of less than six articulations. The head of the workers is usually very large. The species which serves as the type of the genus in the works of Fabricius, Jurine, and Latreille, is the *fourmis de visite*, or *Atta cephalotes* of systematic writers. It is a foreign insect, and seems to agree with that figured by Madame Merian.[1] This creature burrows in the earth, to the extent, it is said, of six or eight feet. It however leaves its subterranean dwelling for a time once a year, and enters dwelling-houses, where it attacks and destroys every other kind of inconvenient insect. If during these predatory incursions they find an intervening space which they cannot cross, a party volunteer to form a chain of their own bodies linked together, over which, as by a bridge, the main body passes.

6*th*, The genus CRYPTOCERUS of Lat., of which the species are also furnished with a sting, and have the abdomen of the pedicle formed of two knots; but the head, which is large and flat, has a groove on each side for the reception of a part of the antennæ. They are peculiar to South America.[2]

The other Heterogyna live in solitude, and each species is composed of only two kinds of individuals, winged males and apterous females,—the latter always provided with a strong sting. The antennæ are filiform or setaceous, vibratile, with the first and third articulations elongated; the length of the former, however, never equalling that of the third part of the total length of the antennæ. They form the genus *Mutilla* of Linnæus, which has been subdivided into DORYLUS, Fab. (Plate CCXLV. figure 6), peculiar to Africa and the East Indies; LABIDUS, Jurine, proper to South America; and MUTILLA properly so called (ibid. fig. 5). Of the latter, *M. Europæa*, Linn., is black, with a red thorax, and three white bands on the abdomen. The female is armed with a powerful sting. The manners of the Mutillæ seem little known. We are not ourselves acquainted with the nature of their metamorphosis. They love warm sunny places, and sandy soils. The females being apterous, are always found pon the ground, concealed under stones, or lurking in little holes. The males are seen on flowers, or by the sides of dusty paths, and other places frequented by the females. The genus is extensive, Olivier and Klug having described a great many species.[3]

FAMILY II.—FOSSORES.[4]

This family comprises such of the stinging Hymenoptera as are winged in both sexes, and of solitary habits. The legs of several are adapted for digging. The ligula is always more or less widened at the extremity, and never filiform or sectaceous. The wings are always extended. The old genus SPHEX is the principal representative of this family.

The females of these insects deposit their eggs in little prepared chambers in the earth or in wood, and place alongside of them a supply of insects or their larvæ. They also pierce spiders with their stings, and close them up as provision for their young. The larvæ are without feet, and spin a cocoon before passing into the nympha state. The perfect insects are in general extremely active, and live among flowers. The maxilla and the labium are elongated, and assume in several the form of a trunk. The numerous minor genera derived in recent times from the genus just named, are distributed by Latreille into seven principal tribes.

[1] *Insectes de Surinam*, ed. of 1726, p. 18, tab. 18.
[2] Besides the article ANT of this work, see the noted volume by Huber the younger, entitled *Recherches sur les Mœurs des Fourmis indigènes*, and Latreille's *Histoire Naturelle des Fourmis*.
[3] In *Encyclop. Méth.* and *Act. Phys. Med. Acad. Cæsar. Leopold*, t. x. pars 2. Latreille has also published a monograph of the French species in the *Actes de la Soc. d'Hist. Nat. de Paris*, and a great number are figured by Coquebert in his *Iconographia Insectorum*.
[4] From *fossor*, a digger.

Hymenoptera Aculeata.

In the first two the eyes are often emarginate. The body of the males is usually narrow, elongated, and terminated posteriorly, in a great number, by three spinous points or dentations.

TRIBE 1ST, SCOLIETES, Lat.

The first segment of the thorax is sometimes in the form of a bow, and prolonged laterally as far as the wings, sometimes of a transverse square, or resembling a knot or articulation. The legs are short, thick, very spiny or ciliated, with the thighs arched near the knee. The antennæ are sensibly shorter than the head and thorax in the females. The genera are TIPHIA, Fab. (Plate CCXLV. figure 7); MYZINE, Lat.; MERIA, Illiger; and SCOLIA, Fab. (ibid. fig. 8).[1]

TRIBE 2D, SAPIGYTES.

The first segment of the thorax is formed like that of the preceding group, and the legs are also short, but slender, and neither spiny nor strongly ciliated. The antennæ in both sexes are at least as long as the head and thorax. The body is usually either smooth, or but slightly pubescent. The genera are THYNNUS, Fab.; POLOCHRUM, Spinola; and SAPYGA, Lat.

TRIBE 3D, SPHEGIDES, Lat.

These still resemble the preceding in the extent and form of the first segment of the thorax; but the posterior legs are at least once again as long as the head and thorax. The antennæ are often slender, formed of lengthened articulations, lax, or not compactly set, and curved or arcuated, at least in the males.

Of this tribe a certain number have the first segment of the thorax of a square form, whether transverse or longitudinal, and the abdomen is attached by a very short pedicle. The inner side of the posterior tibiæ is usually furnished with a brush or pellet of hairs. The upper wings have three or two complete or closed cubital cells, and a terminal one which is imperfect. The genera are PEPSIS, Fab. (Plate CCXLV. figure 9), of which the species, abundant in South America and the Antilles, are large, with coloured wings; CEROPALES, Lat.; POMPILUS, Fab. (ibid. fig. 10), of which the species feed their young with spiders; PLANICEPS, Lat.; and APORUS, Spinola.

Others of the same tribe have the first segment of the thorax narrowed in front, in the form of a knot or joint; and the first segment of the abdomen, and sometimes even a portion of the second, narrowed into an elongated pedicle. The upper wings always exhibit three complete cubital cells, and the commencement of a fourth. The genera are, AMMOPHILUS, Kirby, of which we may mention, as an example, *Sphex sabulosa*, Linn., the female of which digs holes in the earth by the sides of paths and highways, in which she deposits a caterpillar mortally wounded, and then lays an egg beside it,—the said egg soon producing another larva, which, though much smaller, being in good health, immediately eats the sick one; SPHEX, PRONÆUS, CHLORION,[2] and DOLICHURUS, Lat.; AMPULEX, Jur.; PODIUM and PELOPÆUS, Lat.

TRIBE 4TH, BEMBECIDES, Lat.

In these the first segment of the thorax forms only a linear and transverse border, of which the two lateral extremities are distant from the origin of the upper wings. The legs are always short, or of moderate length. The head, seen from above, appears transverse, and the eyes extend as far as the exterior border. The abdomen forms an elongated semi-cone, rounded on the sides, near the base. The labrum is entirely exposed, or very salient.

Of this tribe the species are characteristic of the warmer countries of the earth. Their body is elongated, pointed posteriorly, almost always varied with black and yellow, or reddish, and smooth. The antennæ are approximate at the base, slightly geniculate at the second article, and enlarged towards the extremity. The mandibles are narrow, lengthened, dentated on the inner side, and crossed. The tibiæ and tarsi are provided with little spines or cilia, which are particularly obvious on the anterior tarsi of the females. There are frequently one or two raised teeth beneath the abdomen of the male. The flight of these insects is extremely rapid, and they dart from flower to flower with a sharp and interrupted sound. Several species smell of the odour of roses.

In a certain number we find a false trunk, bent underneath, with the labrum in the form of an elongated triangle.

Of these, some have the palpi very short; the maxillary possessing four, the labial two articulations. Such is *Bembex rostrata*, Fab. (*Apis rostrata*, Linn.), Plate CCXLV. fig. 11, a large black insect, with transverse bands of citron yellow upon the abdomen. This is a well-known European species. The female digs deep holes in a sandy soil, in which she places the carcasses of other insects, especially Syrphi, and other two-winged flies. Among these she lays her eggs, and then places a plug in the hole. Another hymenopterous insect, however, *Parnopes carnea*, possesses a strong instinctive desire to deposit her eggs in the subterraneous nest of the Bembex. As soon as the latter perceives its natural enemy hovering around its dwelling, it attacks it with the greatest fierceness, and endeavours to thrust its sting through its body,—an attempt, however, which is seldom successful, owing to the hardness of the Parnopes's skin. Others have the maxillary palpi elongated, and with six articulations,—the labial with four. Such is the genus MONEDULA of Lat.

In the remainder of this family there is no false trunk, and the labrum is short and rounded, *e. g.* the genus STIZUS of Jurine.

TRIBE 5TH, LARRATES, Lat.

These in their general aspect resemble the preceding, but their labrum is either entirely or in great part concealed, and there is a deep emargination on the inner side of the mandibles,—a character which distinguishes them both from those which precede and those which follow.

In some the upper wings have three closed cubital cells, of which the second receives the two recurrent nervures. Such are the genera PALARUS, Lat., LYROPS, Illiger, and LARRA, Fab. (Plate CCXLV. figure 13). In others the upper wings have only two closed cubital cells, each of which receives a recurrent nervure. Such are DINETUS and MISCOPUS, Jurine.

TRIBE 6TH, NYSSONES, Lat.

In this family the labrum is likewise entirely or in great part concealed. The maxillæ and labium do not form a trunk, and the mandibles have no emargination on the inner side. The head is of ordinary size, and the abdomen is triangular or ovoid-conical, becoming gradually narrower

[1] For the anatomy of the Scoliæ, see Dufour's Observations in the *Journal de Physique* for September 1818.

[2] For the singular habits of *C. compressum*, common in the Isle of France, where it attacks, slays, and carries off cockroaches to its young, see Sonnerat's *Voyage aux Indes Orientales*; Réaumur's *Mémoires*, t. vi. p. 280; or the *Dict. Class. d'Hist. Nat.* t. iv. p. 42.

from the base towards the extremity, and never borne upon a long pedicle. The antennæ are filiform, with the first articulation slightly elongated.

In the genera Astata, Nysson, Oxybelus,[1] and Nitela, Lat., the eyes are entire; in Pison of Spinola they are emarginate.

Tribe 7th, Crabronites, Lat.

In this, the concluding tribe of Fossores, the head is usually very large, and when viewed from above seems almost square. The antennæ are often enlarged towards the extremity, or club-shaped. The abdomen is either oval or elliptical, and broadest about the middle,—or narrowed at the base into a lengthened pedicle, and as if terminated by a club.

In some the antennæ are inserted beneath the middle of the anterior part of the head, and the chaperon is short and broad. In the genus Trypoxylon, Lat. the eyes are emarginate. Of these, one of the most remarkable is *T. figulus* (*Sphex figulus* of Linn.), Plate CCXLV. figure 13. The female deposits her eggs in holes in old timber, along with a supply of little spiders, which she closes up with moist earth. In the remainder the eyes are entire. In the genus Crabro of Fab. (ibid. fig. 15) many of the males are remarkable for a peculiar dilatation of the anterior tibiæ, resembling a slender shell, convex without and concave within, and pervaded by a multitude of little holes, or rather of transparent points. They somewhat resemble the well-known expansions on the fore-feet of the male Dytisci, and probably serve for the same end.[2] In the perfect state these insects seem to feed on the nectareous juices of flowers; but the larvæ are extremely greedy of animal food. The female parent forms holes in the earth, in each of which she deposits an egg along with the body of a captured insect. She then, as usual, closes up the orifice, and the entombed prey, whether dead or alive, is soon attacked and eaten by the young larva to which the egg gives birth. Dipterous insects form their most frequent food, although *C. cribrarius* is observed to seize upon the caterpillar of a *Pyralis* which inhabits the oak. Walckenaer observed several species hovering incessantly around the nests of a solitary bee named *Halictus terebrator*, which they seemed much inclined to enter.[3] The remaining genera of this division of the Crabronites are Stigmus, Jur.; Pemphedron, Lat., of which *P. unicolor* feeds its young on Aphides; Mellinus, Fab. (Plate CCXLV. figure 16); and Alyson, Jurine.

In other Crabronites the antennæ are inserted higher up or towards the middle of the face, and are usually enlarged towards the termination, or even club-shaped. In the genus Psen of Lat. the clypeus is almost square, and the abdomen is borne upon an abruptly formed and elongated pedicle, composed of the first segment. The mandibles terminate in two teeth. In Philanthus of Fab. the clypeus is trilobed, and the first segment of the body is at most restricted in the manner of a knot. The mandibles terminate in a simple point. The females of this genus dig holes in the sand, in which they bury the carcasses of bees, Andrenæ, and even of Curculionides, for the nourishment of their young.[4]

Family III.—Diploptera.[5]

This is the only family of the section in which the upper wings are longitudinally folded.[6] The antennæ are generally geniculate, and clubbed, or enlarged towards the extremity. The eyes are emarginate. The prothorax is prolonged posteriorly on each side to the origin of the wings, of which the superior have three or two closed cubital cells, the second of which receives the two recurrent nervures. The body is smooth, or nearly so, black, and more or less spotted with yellow or fawn colour. Many of the species dwell in temporary societies, composed of three kinds of individuals, males, females, and workers or neuters. A few females which have withstood the rigour of the winter season commence the building of the nest, and attend to the young first produced, which are usually neuters—and these speedily aid their parent in all matters of household management. The family is composed of two tribes.

Tribe 1st, Masarides.

In these the antennæ seem at first sight to be composed of only eight articulations; the eighth forming with the ensuing ones an almost solid mass, rounded or obtuse at the end, with the articulations indistinct. The ligula is terminated by two threads capable of being withdrawn within a tube formed by its base. The upper wings have only two complete cubital cells. The middle of the anterior margin of the clypeus is emarginate, and receives the labrum in that emargination. The genera are few in number. In Masaris proper (Plate CCXLV. figure 17), the antennæ, a little longer than the head and thorax, have the first article lengthened, and the eighth forming an obconic club, rounded at the extremity. The abdomen is long. In Celonites, Lat. the antennæ are scarcely longer than the head, and their first two articulations are much shorter than the third; the eighth and following form an almost globular body. The abdomen is scarcely longer than the thorax.

Tribe 2d, Vespiariæ.

In these the antennæ always exhibit distinctly thirteen articulations in the male and twelve in the female, and terminate in an elongated mass, pointed, and sometimes hooked (in the males) at the end; they are always geniculate, at least in the females and neuters. The ligula is sometimes divided into four plumose filaments, sometimes into three lobes, having four glandular points at the end, one on each lateral lobe, and the two others on the intermediate one, which is larger, widened, and emarginate or bifid at the extremity. The mandibles are strong and dentated. The clypeus is large. Beneath the labrum there is a little piece in the form of a ligula, analogous to that which Réaumur observed in certain bees (bourdons), and which M. Savigny names *epipharynx*. With the exception of a small amount of species, the upper wings have three complete cubital cells. The females and neuters are armed with a very strong and venomous sting. Several

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[1] The Oxybeli lay their eggs in little nests in sandy soils exposed to the sun. They store up a collection of dead flies for the use of their young.

[2] See Degeer, *Mémoires*, t. ii. p. 810, pl. 28.

[3] *Mémoires pour servir à l'Histoire Naturelle des Abeilles solitaires.*

[4] We have been under the necessity of doing little more than indicate the names of the generic groups in the family of Fossores. For the details the reader is referred to the corresponding articles in the *Encyclop. Méth.* and the *Diction. Class. d'Hist. Nat.*; to the *Règne Animal*, t. v. pp. 316–32, and more particularly to M. Van der Linden's *Observations sur les Hyménoptères d'Europe de la Famille des Fouisseurs.*

[5] From διπλόος, *double*, and πτερα, *wings*, in reference to the *folding* of these organs.

[6] The character however is not universal,—the genus *Ceramius*, Lat. of which Klug has published a monograph, forming an exception.

species live in societies composed of three kinds of individuals.

The larvæ of these insects are without feet, and each is enclosed in a cell where it is fed, according to its kind, either on the bodies of insects carried thither by the mother at the period of oviposition, or on the nectar of flowers, the juices of fruits and of animal matter, elaborated in the stomach of the parent, or in that of the workers, and carefully supplied from day to day. This tribe corresponds to the genus *Vespa* of Linn.

The genus Ceramius of Lat. differs from all the others in having the superior wings stretched or extended, and in the amount of the cubital cells, of which there are only two. The labial palpi are moreover longer than those of the maxillæ. The species occur in South Africa, and the warmer regions of Europe.[1]

In all the following genera the superior wings are folded, and present three complete cubital cells.

Sometimes the mandibles are much longer than broad, and approximate anteriorly in the form of a rostrum. The ligula is narrow and elongate. The clypeus is nearly heart-shaped or oval, with the point anterior, and more or less truncate. All the species are solitary, and each is composed of only males and females. The latter provision their young both before their birth and during the continuance of the larva state. Their nests are usually formed of earth, and are either concealed in the holes of walls, beneath the ground, in old wood, or are external, and placed on plants. Each nest contains a supply of caterpillars or other larvæ, which the female piles up in a circular form. She sometimes also stores up spiders, which she has the precaution previously to pierce with her sting.

In the genus Synagris, Lat. the ligula is divided into four long plumose filaments, without glandular points at their extremity. The mandibles of some of the males are very large. The species are few in number, and characteristic of Africa. In Eumenes, Lat. the ligula is divided into three portions, glandular at their extremity. The abdomen in some is ovoid or conical, and thicker at the base. Such are Pterochile of Klug, remarkable for the great length of the labium and maxillæ, and for their labial palpi beset with long hairs, and composed of only three distinct articulations. In Odynerus, Lat. those parts of the mouth are much shorter, the labial palpi are nearly smooth, and consist of four perceptible divisions. *Vespa muraria* of Linn. belongs to this genus. It is described by Réaumur.[2] The female perforates deep holes in sand, or in the plaster of walls, at the orifice of which she forms an outer tube, at first straight, afterwards recurved, and composed of an earthy paste, arranged in thick contorted threads. In the cavity of the interior cell she heaps up from eight to twelve little green larvæ of the same age, disposing them in beds one above another, in a circular form. After depositing her egg, she closes the mouth of the hole, and destroys the outward scaffolding. The abdomen in others has its first segment narrow and elongated in the form of a pear, and the second bell-shaped. Such is the genus Eumenes proper, of which *E. coarctata*, Fab. constructs a spherical nest of fine earth on the stems of plants. She fills it with honey, according to Geoffroy, and then deposits an egg.

Sometimes the mandibles, scarcely longer than wide, have a broad oblique truncation at their extremity. The ligula is short, or but slightly elongated. The clypeus is almost square. These insects constitute the genus Vespa, or wasps properly so called. They unite in numerous associations, composed of males, females, and neuters. The last two kinds detach particles of old wood or bark with their mandibles, reduce and moisten them to the consistence of a paste resembling paper or pasteboard in its nature, and construct nests containing horizontal combs suspended from above by one or more pedicles; on the inferior side there is a range of vertical cells in the form of hexagonal and truncated pyramids. These cells serve solely as lodgings for the isolated larvæ and nymphs. The amount of combs forming the same nest varies; and the nest itself is sometimes open or exposed, sometimes surrounded by an envelope, pierced by a common and almost always central opening, which corresponds with a string of holes for the purposes of internal communication, if the edges of the combs adhere to the inner side of the external covering. These singular constructions are sometimes suspended to the branches of plants in the open air, sometimes concealed beneath the earth or in the hollows of old trees. Their form likewise varies according to the species.

The females commence their labours in spring, and in the first place in a state of solitude. In a nest of small dimensions they deposit the eggs of neuters or workers, which, as soon as they are hatched and attain maturity, enlarge the dwelling, and assist in rearing additional members of the body politic. For a considerable time the society consists only of the original founder of the colony, that is, the female parent, and of neuters. Towards the end of summer or beginning of autumn, young males are hatched, along with additional females. But all such larvæ and nymphs as have not completed their final metamorphosis before the month of November are murdered by the neuters, and torn from their cells. These destroyers are themselves ere long destroyed, in common with the males, by the first frosts of winter. The latter sex never work. A few females alone survive the rigours of the winter season, and these again, on the return of spring, become each the founder of a new but equally transitory empire. Of the death and desolation which is so soon to overtake their busy race, the *genus irritabile* is, however, all unconscious during the glad summer days, or those of the *fruitful* autumn, in which they ply their never-ceasing labours:—

> So fails, so languishes, grows dim, and dies,
> All that this world is proud of;

and hymenopterous and human kingdoms, alike decay and perish. The polity of wasps, we may observe, is not so exclusively monarchical as that of bees. It partakes rather of the republican order, as many females dwell together in amity during the autumnal season. These Vespæ are almost omnivorous. They prey on other insects, on flesh and fruits of every kind, especially when ripe and sweet. They appear to an uninstructed eye as very gluttonous; but their apparent greed becomes more excusable, when we consider that they are catering, not for themselves, but for a numerous and otherwise unprovided offspring. The larvæ, in consequence of the peculiar position of the opening of their cells, lie in a reversed position, with their heads downwards. When about to pass into the nympha state, they shut up their cells, and fabricate a cocoon.

In several species, that portion of the inner margin of the mandibles which is beyond the angle, and terminates it, is shorter than that which precedes the angle. The central part of the front of the clypeus is pointed. These belong to the genus Polistes of Lat. and Fab. in which we class *P. morio* from Cayenne. Its nest is large, in the form of a truncated cone, pierced inferiorly and at one side. It is composed of very thick pasteboard. Here also are

[1] See Klug's *Entomologische Monographien*, p. 219, et seq.

[2] *Mémoires*, vi. xxxvi. 1–10.

placed the *Vespa gallica* of Linn. and the *V. nidulans* of Fab. *P. Lecheguana*[1] is a species which we owe to M. Aug. St Hilaire, who brought it from the interior of Brazil. Its combs contain an excellent honey, resembling in consistence that of our own domestic species, but possessing at times the singular quality of rendering those who eat it furious, or void of reason. It has been known from ancient times that common honey is occasionally possessed of very deleterious properties, arising probably from the nature or condition of the flowers from which it is collected. The naturalist just named, and two men by whom he was accompanied, nearly perished in consequence of eating of the Brazilian honey in its poisonous state.

In other wasps the superior portion of the inner margin of the mandibles, or that which succeeds the angle, is as long if not longer than the other portion of that margin. The central part of the front of the clypeus is widely truncated. The abdomen is always ovoid or conical. These constitute the genus Vespa properly so called, of Latreille. The French entomologist here places the *V. crabro,* Linn, which we call the *hornet.* (Plate CCXLV. fig. 18.) It builds its nest in sheltered places, such as barns, old walls, wooden posts, and hollow trees. It is of a roundish shape, composed of coarse materials, and resembles an old leaf in colour. This species devours other insects, and robs bees of their honey. Though a well-known English insect, it has not yet been found in Scotland. The common wasp, *V. vulgaris* (ibid. fig. 19), forms a somewhat similar nest; but it is composed of finer paper, contains a greater number of combs, and is sheltered in a hole in the earth. *V. media,* Lat. is intermediate as to size between the two preceding. It hangs its paper dwelling beneath the branch of a bush or tree. The nest of *V. holsatica,* Fab. is worthy of a brief record. It is almost globular, pierced at the top, and enclosed beneath in a kind of saucer. It is sometimes observed abroad, in barns, or attached to the beams of garrets, and has even been found in hives. It is not unknown in Britain.

FAMILY IV.—ANTHOPHILA,[2] Lat.

In this, the last family of the stinging Hymenoptera, we find a peculiar power existing in the two posterior legs,—that of collecting the pollen of flowers.[3] This character distinguishes our present groups from those of every other family of insects. The first articulation of the tarsi of the hinder legs is very large, compressed, and in the form of a square pallet, or of a reversed triangle. The maxillæ and the labium are usually very long, and constitute a kind of trunk. The ligula is generally shaped like the head of a lance, or resembles a lengthened filament, of which the extremity is silken or hairy. The larvæ are fed exclusively on honey, or the fecundating pollen of flowers. The perfect insects restrict their own diet to the nectareous juices of flowers, and (when Flora's kingdom has fallen before the approach of winter) to the secretion which they form from these, which we call honey. These Hymenoptera, embracing the great genus Apis of Linnæus, are divided by Latreille into two sections.

Section 1st, Andrenetæ, Lat.

The genera of this section have the intermediate division of the ligula heart-shaped or lance-shaped, shorter than the sheath, and bent upwards in some, almost straight in others. They correspond to the *Pro-abeilles* of Réaumur and Degeer, the Andrenæ of Fabricius, and the Melittæ of Kirby.[4]

The Andrenetæ are solitary insects, and consist of only males and females. Their mandibles are simple, or terminated at most by two dentations. The labial palpi resemble the maxillary, and the latter have six articulations. The ligula is divided into three portions, of which the lateral are short, and in the form of auricles. The majority of the females collect the pollen of plants by means of the hairs of their hinder legs, and mixing it with a little honey, they thus form a paste for the nourishment of their young. They form holes in the ground, frequently even in firmly-trodden places by the sides of roads, or in fields, and of considerable depth. In these they place their paste, and depositing an egg along with it, they close up the entrance with earth.

Some have the middle division of the ligula widened at the extremity, almost heart-shaped, and doubled in repose. Such is the genus Hylæus, Fab. which is now partitioned into two. In the first, or Hylæus properly so called (Plate CCXLV. figure 20), the body is smooth, the second and third joints of the antennæ of almost equal length, and the upper wings present only two complete cubital cells. The species being hairless, do not collect pollen, and seem to deposit their eggs in the nests of other Hymenoptera of this family. In the second genus, Colletes, Lat. the body is hairy, the third article of the antennæ exceeds the second in length, and the upper wings present three complete cubital cells. The females collect their stores from flowers. Such is the *Apis succincta* of Linn.—"l'abeille dont le nid est fait d'espèces de membranes soyeuses," of Réaumur.[5] The male is distinguishable by his more lengthened antennæ. The female forms in the earth a cylindrical hole, of which the walls are endued with a gummy liquid, which has been compared to the viscous and shining slime left by slugs on the places over which they have passed. She then forms a number of thimble-shaped cells, apparently composed of the same material, placed end to end, and in a string, and each containing an egg and a suitable portion of paste.

Other Andrenetæ are distinguished from the preceding by the form of the ligula, which is lanceolate. In some of these, that part is folded on the superior side of the sheath, as in the genera Andrena and Dasypoda of Lat. (Plate CCXLV. figure 21). The females of the latter have the first joint of the tarsi very long, beset with lengthened hairs after the manner of a little feather. The upper wings in both these genera have only two cubital cells. The *Andrena flessæ* of Panzer, common in the environs of Paris, secretes a peculiar kind of honey, black and oily like the grease (cambois) used for carriage-wheels. It has a narcotic odour. In others the ligula is straight, or slightly bent underwards at its extremity. Such are the genera Sphecodes, Halictus, and Nomia, of Latreille.

Section 2d, Apiariæ, Lat.

In this second section of the honey-making Hymenoptera the genera are characterized by the middle division of the ligula being at least as long as the mentum or its tubular sheath, and setiform or filamentary. The maxillæ and labium are greatly elongated, and form a sort of trunk, geniculate and bent beneath while not in action. The

[1] *Ann. des Sciences Nat.* t. iv. p. 339.

[2] From ανθος, *flower*, and φιλος, *lover.*

[3] Latreille remarks that the parasitical species are not possessed of this faculty;—but the form of their legs is essentially the same, those parts being merely destitute of the hairs or brushes.

[4] *Monographia Apum Angliæ.*

[5] *Mémoires*, vi. xii.

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two first articulations of the labial palpi have generally the form of a scaly and compressed seta, which embraces the sides of the ligula; the two others are very small, and the third is usually inserted near the exterior extremity of the preceding, which terminates in a point.

The Apiariæ are either solitary, or united in society.

A.

In the former, which constitute the first principal division, the species consist of only two kinds of individuals, of the ordinary nature of male and female. Each female provides, by her own unassisted efforts, for the preservation of her posterity. The posterior legs are unprovided with the silky down (la brosse) on the inner face of the first articulation of the tarsi; neither do we perceive that particular depression on the outer side of the tibiæ, which the French naturalists distinguish as *la corbeille*, or the basket, and which is so useful in the economy of the *workers* in certain other genera. That outer side, as well as the corresponding part of the first articulation of the tarsi, is usually furnished with numerous close-set hairs.

a.

The first subdivision of these solitary Apiariæ consists of species in which the second articulation of the posterior tarsi of the females is inserted in the centre of the extremity of the preceding one; the exterior and terminal angle of the latter does not appear dilated or more advanced than the interior.

*

We shall first signalise a group of genera which have been named *Andrenoides*, no doubt from the resemblance which they bear to the latest of the preceding genera in their labial palpi, composed of slender linear joints, placed end to end, almost entirely similar to those of the maxillary palpi, and which are six in number. The labrum is always short. The females have no brush on the abdomen; but their posterior legs are clothed or garnished with tufts of hair, which serve them to collect the pollen of flowers. Some have the mandibles narrow, contracted towards the extremity, terminated in a point, and, in common with the labrum, smooth. Such are the genera Systropha, Illig. Rophites, Spinola, and Panurgus, Panzer. Others have the mandibles, in the females, almost spoon-shaped, very obtuse, carinated or grooved, and bidentated at the end. The labrum is very hard, and ciliated above. The antennæ are strongly geniculate and filiform. The upper wings have three complete cubital cells, the first intersected by a little transparent line, the second triangular, the third the largest, and receiving the two recurrent nervures. The genus Xylocopa, Lat. (Plate CCXLV. figure 22), resemble large humble-bees. Their body is usually black, sometimes covered in part with a yellow down, and the wings are frequently adorned by brilliant tints of violet, copper, and green. The males of several species differ greatly from the females. Their eyes are large, and more approximated superiorly. Their anterior legs are dilated and ciliated. The species figured, which is the *Apis violacea*, Linn. is one of the best known in European countries. The female excavates holes in old wood, divided into several cells, in each of which she deposits an egg, and a portion of paste for the sustenance of the future grub. The species are very numerous in foreign countries, and seem to spread over many regions of the globe. Comparatively few occur in Europe.

* *

In other genera the labial palpi appear under the form of scaly setæ; the first two articulations are very large, or much lengthened, compared to the last two, of a scaly consistence, with the margins membranous or transparent. The maxillary palpi are always very short, and have not unfrequently fewer than six articulations. The labrum in a great number is lengthened, inclined upon the mandibles, sometimes in the form of an elongated square, sometimes of a lengthened triangle.

The group named *Dasygastræ* by Latreille are remarkable, as their name implies, in this, that the abdomen of the female is almost always furnished with numerous short, close-set hairs, which form as it were a silky brush. The labrum is as long or longer than broad, and of a square form. The mandibles of the females are strong, incisive, triangular, and toothed. The paraglossæ are always very short, in the form of scales, pointed at the end. Of all the genera which compose this group, that called Ceratina approaches most closely to that of which we last figured an example; and, according to Maximilian Spinola, the habits of the females are identical with those of the Xylocopæ.[1] We have several species in Britain. All the remaining *Dasygastræ* have at most only four articulations to the maxillary palpi, and two complete cubital cells. In the six genera next ensuing, the abdomen is obviously furnished beneath with a silky brush. The species belonging to Chelostoma, Lat. and Heriades, Spin. form their habitations in the hollows of ancient trees. In the genus Megachile, Lat. the maxillary palpi are composed of only two articulations, the abdomen is plain above, and susceptible of being raised upwards,—thereby enabling the female to use her sting over her body. This genus contains several singular insects, of which the habits have been well described by Réaumur and other observers.[2] *M. muraria* is one of the largest of the genus. The female is black, with dark wings tinted with violet; the male is covered with reddish hairs, the terminal segments of the abdomen being black. The former sex constructs her little nest on walls and stones in sunny places. It is made of fine earth worked into a kind of mortar, which drying, becomes very hard and durable. On this account the term *mason-bee* is applied to this insect, and to several other species of analogous habits. The interior of these nests contains about a dozen cells, in each of which the provident parent deposits an egg and a piece of paste. The perfect insect is not produced till the spring of the ensuing year. Another species, *M. sicula*, Lat. is black and hairy, with the front, the upper part of the thorax, and the legs, bright yellow. The female constructs a hard and spherical nest, of rather more than an inch in diameter, which she attaches to the branches of heath and other plants. This insect occurs both in Egypt and the south of Europe, and was lately noticed in Corsica by M. Payraudeau. The habits of other species of the genus Megachile are very different from those just noted. They are known by the name of *leaf-eating bees* (Plate CCXLV. figure 23), on account of their employing in the construction of their nests perfectly oval or circular pieces of leaves, which they cut out with the most remarkable dexterity. These pieces are conveyed to their straight cylindrical holes, which they previously excavate in the earth, or sometimes in walls, or the decayed trunk of an old tree. They line the bottom of the cavity with these cuttings, and form a thimble-shaped cell (ibid. fig. 27), in which they deposit the honeyed provision on which the larva is destined to feed. After laying an egg, they close the cell by means of a flattish or slightly concave lid, also formed of a portion of leaf. These little cells are repeated one over the other till the hole is filled up. To this division of the genus belongs the *M. du rosier* of Lat. (*Apis centuncularis*, Linn.). The genus Lithurgus, Lat. is furnished with four articulations to the maxillary palpi, and the abdomen is depressed above. All the articulations of

[1] See the article *Ceratine*, in the 2d edition of the *Nouv. Dict. d'Hist. Nat.*

[2] *Mémoires*, t. iv.

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the labial palpi are placed end to end. The females have a rounded projection in the middle of the head. Such are *Centris cornuta*, Fab. and an unpublished species from the Isle of France, alluded to by Latreille. In the genus OSMIA of Panzer the maxillary palpi consist of four articulations, or at least of three very distinct ones, and the abdomen is convex above. The habits of the species have been observed by Réaumur, Degeer, Spinola, and other naturalists. Several are *masons*, and have frequently two or three horns on the clypeus, which are probably of use in the construction of their nests. These are concealed in the earth, in chinks of walls, door-posts, and old wood, and sometimes even in the shells of snails (*Helices*). One of the most interesting of the genus is the *Osmia papaveris*, which lines its subterranean dwelling with the gorgeous petals of the scarlet poppy. Another, *O. gallarum*, takes possession of a fungous gallnut formed by a kind of Cynips which inhabits the oak. The hollow space left by the Cynips being too small, the little bee enlarges it considerably, and polishes the interior. The genus is composed of about thirty species, which seem almost peculiar to Europe. A considerable number occur in Britain. The other genera of this group are ANTHIDIUM, Fab., STELIS, Panzer, and COELIOXYS, Lat.[1] The two last-named genera of Dasygastræ resemble the ensuing group in wanting the silky brush, from which it has been presumed that they also coincide with them in being parasitical; but their labrum is parallelogramic, and the mandibles are triangular and dentated. The maxillary palpi are very short and biarticulate.

* * *

A third group of genera in this subdivision of the (solitary) Apiariæ is named *Cuculinæ*. They resemble the preceding in the posterior tarsi, and agree with the concluding genera in the labial palpi being in the form of squamous setæ; they also resemble the genera *Stelis* and *Coelioxys* in the abdomen being destitute of a silky brush. They are parasitical, and their bodies are almost smooth and coloured like those of wasps, sometimes partially clothed or hairy. The labrum assumes the form of a lengthened and truncated triangle, or is short and almost semicircular. The mandibles are narrow, ending in a point, and at most unidentated on the inner side. The paraglossæ are often long, narrow, and setiform. The scutellum in several is emarginate or bidentated; in others it is tubercular. These insects correspond to the *Nomadæ* of Fabricius. Several appear in those countries to which they are indigenous, flitting about in spring partly near the ground, or on walls exposed to sunshine. They are then employed in searching for the nests of other Apiariæ, in which they, cuckoo-like, deposit their eggs. It was in reference to this habit that Latreille named them Cuculinæ. The genera are AMMOBATES, PHILEREMUS, EPEOLUS, Lat., NOMADA, Fab. (Plate CCXLV. figure 24), PASITES, Jur., MELECTA, Lat., CROCISA, Jur., OXÆA, Klug.[2] Of these, Nomada is the richest in British species. The genus occurs in Asia, Africa, and America, although the majority are characteristic of, if not peculiar to, Europe. The genus Melecta is not unknown in Britain.

b.

The concluding subdivision of the solitary bees is characterized by the first article of the posterior tarsi being dilated inferiorly on the outer side, so that the following articulation is inserted nearer to the internal angle of its extremity than to the opposite one. The outer side of that first angle, as well as the corresponding part of the tibiæ, is furnished with thick and close-set hairs, forming, especially in several exotic species, a sort of brush or tuft,—and thence the name of *Scopulipedes*, bestowed on this division by Latreille. The under part of the abdomen is naked, or at least unprovided with a silken brush. The number of cubital cells is three, with few exceptions, and each of the last two cells receives a recurrent nervure.

Sometimes the maxillary palpi consist of from four to six articulations.

In a certain number the mandibles exhibit only a single tooth on the inner side. These species fly with great rapidity from flower to flower, and with a buzzing sound. They construct their nests either under ground, or in the clefts of old walls. Several prefer ground which has been cut perpendicularly, and exposed to the sun. Those species in which the two lateral portions of the ligula are as long as the labial palpi, and setaceous, and of which the antennæ of the males are lengthened, form the genus *Eucera* properly so called (Plate CCXLV. figure 25). The male of a British species (*Apis longicornis*, Linn.) is black, with the labrum and the anterior extremity of the head yellow; its upper portion, thorax, and two first segments of the abdomen, are covered by a reddish down. The female (at one time described by Fabricius as a distinct species, under the name of *Apis tuberculata*) has short antennæ. The maxilla and labium form at their base a slight projection. The abdomen is marked by grey stripes, with a reddish termination. Several other species occur in Britain. Spinola has detached certain species, of which the maxillary palpi have only five distinct articulations, and the superior wings only two cubital cells. These he names MACROCERA.[3] The MELIPODES of Lat. may be defined as American Euceræ, with but four joints to the maxillary palpi, and three cubital cells to the superior wings. In the other Apiariæ of this subdivision, the paraglossæ are much shorter than the ligula, and always exhibit three cubital cells. In MELITTURGA and ANTHOPHORA, Lat. (of both of which several species are indigenous to Britain), the maxillary palpi have six articulations. In SAROPODA, Lat., likewise known among ourselves, the maxillary palpi have only five articulations, and those of the labium are continuous. Lastly, in the genus ANCYLOSCELIS, Lat., of which the species are native to Brazil, the maxillary palpi offer only four articulations.

In others the mandibles have several dentations on the inner side, and the maxillary palpi, as in the preceding genus, have four articulations. Such is the American genus CENTRIS of Fab.

Sometimes the maxillary palpi consist of only a single very small articulation, which even becomes imperceptible in certain species. The paraglossæ are very short, and the mandibles dentated. Such are the genera EPICHARIS and ACANTHOPUS of Klug.[4]

B.

Our second principal division of the Apiariæ is constituted by many interesting insects, such as the garden and humble bees, so remarkable for their peculiar *regime*, and the gregarious habits of the species, each of which consists of three kinds of individuals—males, females, and neuters, as the workers are often called. The posterior tibiæ of these last named are furnished on their external face with a smooth depression called the basket, in which they place the pollen

[1] See *Règne Animal*, t. v. p. 350.

[2] For the characters of the above genera, see *Règne Animal*, t. v. p. 352–3; and Kirby's *Monographia Apum Angliæ*. The haunts and habits of the species are noted under their generic titles in the *Encyclop. Méth.*, and the *Diction. Class. d'Hist. Nat.*

[3] The name is objectionable, either on Spinola's part or Meigen's (according to whoever used it last),—as we observe that the German author, in his *Zweiflügeligen Insecten*, applies the same title to a dipterous genus.

[4] See *Encyclop. Méth.* and other works already named.

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collected from flowers by means of the silky down or brush with which the inner face of the first joint of the posterior tarsi is provided. The maxillary palpi are very small, and consist of a single articulation. The antennæ are geniculate.

Sometimes the posterior tibiæ are terminated by two spines, as in the genus EUGLOSSA, Lat. (Plate CCXLV. fig. 26), which has the labrum square, and the false proboscis, or prolonged parts of the mouth, as long as the body. The labial palpi terminate in a point formed by the two other articulations. The species are peculiar to South America. Latreille supposes that we owe to the one which we have here figured (*E. dentata*), and to that called *E. cordata*, the green honey so much esteemed in the Antilles. We are still ignorant of the habits of these insects. In the genus BOMBUS (ibid. fig. 29), the species of which we recognise in this country as *humble-bees*, the labrum is transverse, and the proboscis obviously shorter than the body. The second articulation of the labial palpi terminates in a point, bearing the two others on its outer side. There are few associations of our childhood more deep and lasting than those connected with the pursuit and capture of these beautiful creatures, some of which are remarkable for their size, and the rich contrast which they exhibit of velvet black and crimson, with bars of brilliant yellow. This splendid attire, however, saves them not from being rudely handled; and we remember the day when an artificial *bink*, that is, a little box made of clay, with a piece of glass at one end, and a sprinkling of sugar at the other, contained as many captives in proportion to its size, as the black-hole of Calcutta. But the practice of *blobbing* was one we never patronized, although we know it is pursued in this country, just as it seems to be, judging from the following quotation, by the youth of the *Great Nation* :—" Ils sont bien connus des enfans, qui les privent souvent de la vie pour avoir le miel renfermé dans leur corps, et le sucer.[1] The exciteable genius of a great English poet is roused to a wider range of sentiment and association by the sight of one of these industrious beings.

And is she brought within the power
Of vision ?—o'er this tempting flower
Hovering until the petals stay
Her flight, and take its voice away !
Observe each wing—a tiny van !—
The structure of her laden thigh,
How fragile !—yet of ancestry
Mysteriously remote and high,
High as the imperial front of man,
The roseate bloom on woman's cheek ;
The soaring eagle's curved beak ;
The white plumes of the floating swan ;
Old as the tiger's paw, the lion's mane
Ere shaken by that mood of stern disdain,
At which the desert trembles.—Humming-Bee !
Thy sting was needless then, perchance unknown ;
The seeds of malice were not sown ;
All creatures met in peace, from fierceness free,
And no pride blended with their dignity.
—Tears had not broken from their source,
Nor anguish strayed from her Tartarian den ;
The golden years maintained a course
Not undiversified, tho' smooth and even ;
We were not mocked with glimpse and shadow, then,
Bright seraphs mixed familiarly with men,
And earth and stars composed a universal heaven.[2]

Be this as it may, the species of the genus Bombus inhabit subterranean dwellings, assembled together in social groups amounting to from fifty to sixty individuals, or even in certain cases to between two and three hundred. These unions, however, differ from those of the honey or garden-bee in this, that they are dissolved, like those of wasps, on the approach of winter. They consist of *males*, distinguished by the smallness of their size, their feebler heads, their narrower mandibles, terminated by two dentations, and bearded, as well as by their frequent difference of colour; of *females*, which are larger than the other individuals, and have spoon-shaped mandibles; and of *workers*, of which the mandibles are likewise spoon-shaped, and the size intermediate between the two preceding kinds. Of these workers, Réaumur was the first to distinguish two varieties,—one comparatively large and strong, the other smaller, but more lively and active. This curious fact was afterwards verified by Huber the younger. According to the observations of the Genevese observer, several of the workers born in spring couple during the month of June with males sprung from a common mother, and soon afterwards deposit eggs, from which, however, males alone are produced. These latter couple with the females which are born towards the end of the season, and which continuing through the winter in a pregnant state, become each the founder of a colony in spring. In the mean time, all the others perish, without excepting even the smaller females. The workers, then, though, in common with those of the garden-bee, often called neuters, are in fact females, but of smaller size than the more regular mothers, and with the productive faculty imperfectly developed. No sooner has the genial influence of spring penetrated the mossy cells where these more ponderous matrons have enjoyed their winter sleep, than they rouse themselves from their repose, and wing their dubious flight in search of the first opening crocus, or other garden flower; or, if remote from man, and destined to boom amid wild uplands or other pastoral wastes, the flowering *saughs* (*Salix caprea*), which so often skirt the edges of our mountain streams, and beautify the crystal waters by the reflection of their golden blossoms, afford them a sufficing food. The lover of nature knows how, even among sterile solitudes, a few bright sunny days call into life and beauty many fragrant flowers, not long unvisited by these glad labourers, who ere long settle in some fit abode, and lay the foundations of a future city.

The nests of humble-bees are generally formed beneath the earth, and at a depth of one or two feet. Dry plains, fields, sloping banks, and the sides of hills, are their common localities. These subterranean cavities are of considerable extent, wider than high, and in the form of a dome. The ceiling is constructed of earth and carded moss, carried thither fibre by fibre. The inner walls are plastered over by a coating of coarse wax. Sometimes a simple opening serves as a passage to the foot of the nest; sometimes a tortuous road, of one or two feet in length, leads to the habitation. The bottom of the cavity is lined with a layer of leaves, for the reception of the brood. The female first places in it masses of brown irregular wax, called *pâtée* by Réaumur, and compared to truffles by that naturalist, on account of their shape and colour. Their cavities are destined to contain the eggs and larvæ. The latter live together in society until such time as they are ready to assume the nympha state; they then separate and spin ovoid silken cocoons, vertically fixed against each other. The nymph is always found in a reversed position, or with the head downwards, like those of the females of the honey-bee; and the cocoons are uniformly pierced at their lower end when the perfect insect escapes from its prison. Réaumur asserted that the larvæ fed upon the wax which formed the walls of their habitations; but these, according to M. Huber, merely serve as a protection from cold and moisture; and the actual food consists of an ample provi-

[1] *Règne Animal*, t. v. p. 357.

[2] Wordsworth's *Vernal Ode*.

Hymenoptera Aculeata.

sion of pollen moistened with honey, which the labourers provide for the helpless objects of their instinctive affection. When the supply is exhausted, they pierce the cover of the cells, put in an additional supply, and re-close the protecting habitation. We may truly observe, in relation to these delightful labours, that it is not alone in the "great waters" that man may behold the wonderful works of an omnipotent Creator; for literally the *earth* is "full of his goodness." These affectionate labourers, so pervaded by the instincts of maternity, though themselves for the most part barren, watch like rejoicing mothers over the destiny of the future citizens; and as soon as they perceive that a generous diet has increased their dimensions, they enlarge the size of their habitations. We find moreover in these nests three or four small bodies resembling goblets, composed of brown wax, or of the same consistence as the *pâtée*, always open, and more or less filled with good honey. The exact situation in the hive of these honey jars is by no means constant. It has been said that the workers make use of the empty cocoons for the same purpose; but their doing so is deemed very doubtful by Latreille, in as far as these cocoons are not only formed of a silky substance, but are perforated on the under side.

The larvæ are hatched in about five days after the deposition of the eggs, and accomplish their metamorphoses in the months of May and June. It was formerly supposed that labourers alone were produced at this period; but we have already alluded to the simultaneous production of a certain number of males. The labourers immediately proceed to assist the female founder in her operations; and from this period the number of cells which serve as habitations for the larvæ and nymphs is greatly augmented. They form irregular combs, rising in stages, on the edges of which the pâtée of Réaumur is particularly observable. According to Huber, the workers are extremely greedy of the eggs of the female, and sometimes in her absence open the cells in which they are deposited, in order to suck the milky fluid they contain! a most extraordinary fact, as Latreille observes, and one which seems to belie the noted attachment which they entertain for the germs of that race of which they are the natural and appointed guardians. The wax secreted by humble-bees is elaborated by the same peculiar process as that which produces the more beautiful material with which the garden species constructs its honeyed cells. It in fact results from honey, transuded through the intervals of the rings of the abdomen.[1] Several females dwell together in unity, and do not exhibit that instinctive aversion towards each other so remarkable among our domesticated species.

Yet these bees, however humble, have enemies, numerous and of various kinds. Their habitations are uprooted or otherwise attacked by foxes, badgers, weasels, polecats, rats, field-mice, ants, and moths. Certain *Volucellæ* (*Syrphi* of Fab.) deposit their eggs in their nests, the larvæ proceeding from which devour the eggs of the legal occupants. The larvæ of a species of *Conops*, described by MM. Lachat and Audouin, live, like intestinal worms or the grubs of Strepsiptera, within the abdomen of the perfect bee; and after acquiring wings, they make their escape from between the segments.[2]

The species of the genus Bombus are extremely numerous, and seem extended over almost all the regions of the earth. "Scarcely any genus of the insect creation," observes Mr Kirby, "has so large a range as this of *Bombus*. It is found in the old world and in the new; and from the limits of phænogamous vegetation to the equator; but its metropolis appears to be within the temperate zone."[3] We cannot here enter into descriptive details. In Great Britain alone we have above forty different kinds. Of these, the *B. muscorum* (*Apis muscorum*, Linn.), called *Foggie* by the Scottish schoolboy, is recognisable by its reddish colour, uniform in the males, females, and neuters. In *B. lapidarius* the female is black, the abdomen with a red termination; the male (which is the *B. arbustorum* of Fab.) has the front of the head and both ends of the thorax yellow,—the abdomen having likewise a red extremity. This species differs from the others in its habit of forming its nest under stones. Hence its Latin trivial name. The *B. terrestris* is a very common and very beautiful species, widely distributed. It is black, with the posterior extremity of the thorax and the base of the abdomen yellow. The termination of the latter part is white. The *B. arcticus* of Kirby is black, with the base and apex of the thorax, and the anterior half of the abdomen, pale yellow. This insect is the *Apis alpina* of Otho Fabricius;[4] but not the species so called by Linnæus, which the former author supposed it to be. "The insect before us," says Mr Kirby, "differs so slightly from the description which O. Fabricius has given of that which he mistook for the *Apis alpina* of Linné, that there can be little or no doubt of their identity. He confesses that his specimens (and this bee appears to have abounded in West Greenland, as it was also observed to do in Melville Island, and wherever the expedition landed within the arctic circle) did not in all things agree with the characters assigned to that species. But he states, that as Linné had seen only a single specimen, he did not think himself at liberty to make a new species on account of an insignificant difference. Although, however, Linné had seen this bee only once, it has since been more frequently taken; and having received specimens of it from Sweden, through the kindness of Major Gyllenhal, which agree with the Linnæan description in every point but size (a circumstance easily explained, by supposing the original specimen a queen and those sent to me neuters), I can venture to assert that the two insects are perfectly distinct. *Bombus alpinus* is entirely black, with the upper side of the abdomen, all but the base, covered with orange-coloured or ferruginous hairs. The antennæ also of the female or neuter (an important distinction in a genus the species of which are usually only distinguished by the colour of their hirsuties) are proportionally shorter; and the short hairs that cover the tarsi are black."[5] The range of the true *B. arcticus* seems limited by the arctic circle, and extends from Greenland only in a westerly direction,—at least the species does not appear to have been observed in Lapland, Iceland,[6] or other eastern portions of that chilly zone. A European species, named *B. Lapponicus*, is said to be well known in North America, and to extend as far north as Nova Scotia.[7] Dr Richardson, the intrepid arctic traveller, informed the author of the present treatise, that in the course of the northern land expedition he saw some bees in very high latitudes, resembling our common humble-bee (*B. terrestris ?*), but that he did not at the time ascertain the precise species; and the circumstances under which he was then placed unfortunately prevented his preserving specimens of the softer kinds of insects.[8]

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[1] *Mémoires du Mus. d'Hist. Nat.* t. viii. p. 147.
[2] *Journal de Physique*, Mars 1819.
[3] *Supplement to the App.* to Capt. Parry's *First Voyage*, p. 217.
[4] *Fauna Grœnlandica*, 155.
[5] *Supplement to the App.* to Capt. Parry's *First Voyage*, p. 217.
[6] Hooker's *Recollections of Iceland*, 1st edit. p. 34.
[7] *Dict. Class. d'Hist. Nat.* t. ii. p. 451.
[8] For a detailed history of the genus Bombus, the reader may consult, in addition to the works already named, "Observations on several species of the genus Apis, known by the name of Humble-Bees, and called Bombinatrices by Linnæus," by Mr P. Huber, in *Linn. Trans.* vol. vi. p. 214.

Hymenoptera Aculeata.

The remainder of our social Apiariæ are not characterized, like the preceding, by spines at the extremity of their posterior tibiæ. They form two genera.

In the genus Apis, Lat., or honey-bees *par excellence*, the workers have the first articulation of the posterior tarsi in the form of a lengthened square, and furnished on its interior face with a silky down, or divided into transverse or striated bands. We here place our invaluable garden species *Apis mellifica*, Linn. (of which we have represented the worker, the female, and the drone, on Plate CCXLV. figs. 28, 30, and 31), on the wonderful history and attributes of which we could dilate with pleasure to ourselves, if not with satisfaction to our readers, had not the subject been already here treated of at length, and by an abler hand.[1] We shall merely here remark, that all the species of the genus Apis properly so called are peculiar to the ancient countries of the world, and that the domestic culture of the honey-bee is of an origin so remote as to be lost in the depth of ages. It served among the Egyptians as the hieroglyphical emblem of royalty, and has been more or less attended to by all civilized nations of whom we have any record; for innumerable in all but the darkest times are the writers who have told—

> Of treasure suck'd from buds and bells,
> For the pure keeping of those waxen cells,
> Where she, a statist prudent to confer
> Upon the public weal, a warrior bold,
> Radiant all over with unburnished gold,
> And armed with living spear for mortal fight,
> A cunning forager
> That spreads no waste,—a social builder, one
> In whom all busy offices unite,
> With all fine functions that afford delight,
> Safe through the winter storm in quiet dwells!

Our honey-bee (*A. mellifica*), though now well known in America, is in that country not an indigenous, but an imported species. Our land expeditions did not observe its occurrence to the north of Canada. The Americans have now *settled* the Missouri, as far as the 95th meridian; and it is probable that the New England men, in their journey westward, carried hives along with them. According to Mr Warden, the hive-bee was not found to the westward of the Mississippi prior to the year 1797; but it is now well known, and has been so for a considerable time, as high up the Missouri as the Maka nation,—having proceeded westward six hundred miles in fourteen years.[2] Such a distance seems great for these tiny creatures to advance by the ordinary process of swarming, even supposing that the flight of the new colonies was invariably in a western direction. It is at the rate of forty-three miles a year; but they have perhaps been smitten by the Yankee passion for settling beyond the clearings.[3]

Besides the species above named, various other honey-bees are found in different regions of the earth. The *Apis unicolor* of Lat. occurs in Madagascar and the Isle of France, and yields an esteemed honey of a green colour, like that of the Antilles. The *Apis Indica* of Fab. is found in Bengal and at Pondicherry. The *Apis fasciata* of Lat. is domesticated in Egypt, and is carried at certain seasons, for the sake of a double harvest, from Lower into Upper Egypt, just as we transport our own species, when the "flower-enamelled meads" are on the wane, to the blooming heather of the mountain solitudes. The *Apis Adansonii* is a species found in Senegal; and the *Apis Peronii* is native to the island of Timor, from whence it was first brought by the enterprising navigator whose name it bears. In relation to the European kinds, we have no other British species than the one so frequent in our garden-hives; but the Italians cultivate with success the *Apis Ligustica* of Spinola, which is by some entomologists supposed to occur in the wild state, and unimported, in the Morea and the Mediterranean Archipelago.[4]

Lepidoptera.

The terminal genus of the social bees (and with it we conclude the hymenopterous order) is that called Melipona by Illiger and Latreille. It is distinguished from the preceding genus by the form of the first articulation of the posterior tarsi, which is narrower at the base, or in the shape of a reversed triangle, and without striæ on the silky brush of its interior face. The upper wings have only two complete cubital cells, while there are three in the genus Apis. These Hymenoptera inhabit South America, and build their nests, which resemble bagpipes, on the tops of trees, or in their cavities. Their honey is extremely sweet and agreeable, but very liquid, and apt to corrupt. The Indians form from it a favourite spirituous liquor. These details apply to *M. amalthea*, of which M. Cordier possesses a specimen enclosed in amber. The species in general have been observed by many travellers, but by few naturalists; and it is therefore not very easy to refer the recorded observations on their history to the proper species. Some nearly allied insects form the genus Trigones of Lat.[5]

Order VI.—LEPIDOPTERA, Linn.[6]

This splendid and much-admired order is characterized by the possession of four membranous and veined wings, covered by close-set scales, which frequently present the most brilliant and richly varied colours. The mouth consists of lengthened filaments or threads, the union of which forms an extensile spiral trunk or tongue, with which the nectareous juices of flowers are absorbed. Two palpi (corresponding to the labial palpi of masticating insects), consisting of three articulations, act as a sheath or guard on either side of the tongue when rolled up. The superior or maxillary palpi are usually very small, inconspicuous, or obsolete. The chrysalis is *obtected*, that is, covered over or

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[1] See the article Bee of this work, vol. iv. p. 570. We shall merely observe, in regard to the conversion of the neuter or working bee into a queen-mother, that a great degree of obscurity seems still to pervade the writings of all entomologists, whenever that singular subject is touched upon. Nothing in the history of these creatures has been more clearly demonstrated than the fact of such conversion,—but how a change of food should operate in the course of a few days a determinate change in the organic form and instinctive character of an insect, is as yet a mystery. We are more willing to believe than competent to understand several of M. Huber's facts. It is easy to conceive a greater development of particular organs, the germs of which previously existed,—but the positive alteration in the structure of the feet and maxillæ is not so readily accounted for. We still require some more precise and detailed information regarding this mysterious transmutation than the observations even of the Hubers have furnished. It would tend greatly to elucidate the subject if a series of comparisons could be made at different periods of their development, between the larvæ, nymphs, and perfect insects of the two kinds of queen-bees,—namely, those which were deposited originally in the royal cells (the legitimates), and those whose condition has been altered by the bees themselves in consequence of a failure in the royal line (the citizen-queens). It has not yet been ascertained at what periods or in what manner these singular changes of form take place, further than that the common maggot or bee-worm, on which the change is to be effected, must not exceed the age of three days.

[2] *Statistical, Political, and Historical Account of the United States of America*, vol. iii. p. 139.

[3] *Edinburgh Cabinet Library*, vol. ix. p. 387.

[4] In addition to the numerous works already cited, see a Monograph of the genus by Latreille, in the *Observations de Zool. et d'Anat. Comp. du Voyage de MM. Humboldt et Bonpland.*

[5] *Genera Crustac. et Insect.* t. iv. p. 182.

[6] Glossata, Fabricius.

Lepidoptera.

concealed by a crustaceous envelope, which however exhibits to a certain extent the external traces of the limbs, thorax, and abdomen.

The Lepidoptera are the most beautiful of all insects, and exhibit in their colouring every imaginable hue. It is not the mere brilliancy of the broader masses of colour, or their gorgeous combination, which alone delights our eyes,—but the exquisitely varied markings by which the hand of nature has traced her enigmatical characters on the "sail broad vans" of these fairy and fantastic creatures. What are the forms

Painted on rich men's floors for one feast night,

or the most elaborate Mosaic pavement, when compared with the imbricated surface of a butterfly's wing![1] It was probably the highly ornamental nature of this order that induced Degeer and Olivier to place it at the head of the class of insects.

The mouth of the Lepidoptera does not differ essentially in its structure from the same organ in the masticating or mandibulated orders.[2] Savigny and Latreille have shown, in a manner at once precise and philosophical, that it is composed of the same pieces, and that these pieces are peculiarly appropriated to the functions which they are required to perform; thus some parts of little use exist in a merely rudimentary condition, while others of a more indispensable nature have gained an increase of development. The component parts are: a labrum, often nearly invisible, conical, or subulated; two corneous mandibles, very small, rudimentary, hairy, or garnished with small scales, and fixed, or apparently useless; two corneous maxillæ, in the form of tubular threads, generally much extended, and soldered together as far as the origin of the palpi, and forming by the union of their inner edges the trunk or sucker, of which the interior presents three canals; two maxillary palpi, often almost imperceptible, consisting of from one to three articulations, and inserted near the bend of the maxillæ; two labial or inferior palpi of three articulations, closely set with hairs or scales, and rising on each side of the trunk, of which they form a kind of sheath. The labium is composed of a single piece, flat, and triangular.

The antennæ vary in the different groups, but they are always composed of a great number of articulations. In the diurnal tribes they are simple, and generally terminated by a small inflation or knob; in the crepuscular they assume the form of an elongated or fusiform mass; in the nocturnal they are filiform or setaceous, whether pectinated or simple, and often plumose, especially in the males. In many species we find a pair of stemmatic eyes concealed among the scales, and placed between the ordinary eyes or organs of vision. The latter are hemispherical, of considerable size, and composed of innumerable facettes. The trunk is either ineffective or altogether wanting in some of the crepuscular and nocturnal tribes. The three segments of which the thorax of many other hexapod insects is visibly composed, seem here united into one,—the anterior being very short and transversal, as in the hymenopterous and dipterous orders. The form of the thorax is extremely uniform, and any apparent variety of aspect is caused chiefly by the extension of its hairy or scaly covering, which sometimes assumes the shape of a crest. The abdomen is composed of from six to seven segments. It is attached to the thorax by a very small portion of its diameter, and never offers either sting or ovipositor, although in a few females (as in *Cossus*) the terminal rings are narrow, and lengthened into the form of a pointed and retractile oviduct. The scales of the wings, on which their gorgeous beauty depends, are implanted by means of a small pedicle. Their figure is variable. They are usually somewhat elongated, rounded at the base from the side of the pedicle, and truncated at the outer extremity, which is generally toothed or serrated. The under wings frequently form on their inner margins a kind of canal for the reception of the abdomen. Among many of the diurnal kinds, the four wings, in a state of repose, are raised perpendicularly, so as to meet above the back; in the two other great sections they are horizontal or inclined; and in these there is often a strong spine or bristle on the anterior margin of the inferior wings, which being received by a buckle-like process of the under surface of the superior pair, maintains them in their position.

The legs of the Lepidoptera are as usual six in number, and the tarsi are composed of five articulations, and are terminated by a pair of hooks. In several diurnal genera the anterior pair are much shorter than the others, are useless as locomotive organs, and are folded on the sides of the chest; their tarsi being large, indistinctly articulated, and destitute of apparent hooks. The existence of the sense of smell in the class of insects is clearly demonstrated by the habits of many species of this order. The males of many nocturnal Lepidoptera discover the females of their own kind at a great distance, even when the latter are carefully and intentionally concealed from sight. The female is generally for the most part perceptibly, and in many instances considerably, larger than the males. They deposit their eggs, by an admirable and wisely granted instinct, not on the plants which they themselves affect during their first buoyant courses, but on such as are best adapted for the future nourishment of their crawling and wingless offspring.

The larvæ of Lepidoptera, usually known under the name of Caterpillars, are composed of twelve annular segments, exclusive of the head. They are furnished with nine stigmatic openings on each side, and the three anterior segments of the body are respectively furnished with a pair of short legs of a scaly consistence, terminated by a hook, and corresponding to the true legs of the perfect insect. There are, besides, from four to ten membranous or false feet upon the other segments. The body of caterpillars is generally elongated, soft, almost cylindrical, and frequently adorned by bright or beautiful colours, besides being variously provided with spines, hairs, or tubercles. Many are however naked, or unprotected by any other than a cutaneous covering. The head is harder than the other parts, and is covered by a corneous or scaly skin. It presents on each side six small shining grains, which are regarded as simple or stemmatic eyes; and two very short conical antennæ are likewise perceptible. The mouth is composed of two strong mandibles, a pair of maxillæ, a labium, and four palpi. The food of caterpillars consisting not of vegetable juices alone, but of the actual substance of the leaves and roots, and even of the well-matured woody fibres of timber trees, the masticating organs are beautifully adapted to their functions. But no sooner is the creeping and voracious larva about to transform itself into the "angelic butterfly," which floats on gaudy

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[1] We find the following memoranda among some notes illustrating the difference between the works of art and nature:

The Sussex pavement	contains	11	tessellæ or separate pieces in one inch square.
A modern mosaic picture		870	
The wing of a butterfly expanded		100,736	
The same in the Aurelia state		981,808	

[2] See Plate CCXXXIII. figs 5 and 8. with the detailed description given in the note to page 34 of this volume.

Lepidoptera.

pinions from flower to flower, and sustains itself only on the most ethereal of their nectareous juices, than the parts of the mouth undergo a change not less remarkable than that of the general form and aspect, and the long tubular proboscis above described is developed, in subservience to the habits of a new existence. The change, however, is by no means sudden or immediate, but is effected through the transitionary state of chrysalis, of which we have already said perhaps more than enough in our attempted exposition of the mysteries of transformation. We cannot, however, here avoid to notice the elaboration of that silky substance which, towards the termination of the caterpillar's career, becomes so singular a feature in its natural economy, and one of such vast importance in the artificial *habits* of the human race. It is formed in two long tortuous interior vessels, which, becoming gradually more slender at their upper extremities, terminate in a small conical spinner at the end of the labium. Had these insignificant secreting organs not existed in the silk-worm, or other allied species, what a difference of character would have been manifested in the lustrous aspect of baronial halls, and even of the courts of kings! It is curious, indeed, to consider how the breeding of a few millions of caterpillars should occasion such a disparity at different times in the circumstances of different tribes of the human race. When the wife and empress of Aurelian was refused a garment of silk, on account of its extreme costliness, the most ordinary classes of the Chinese were clad in that material from top to toe; and although among ourselves week-day and holiday are now alike profaned by uncouth forms, whose vast circumference is clothed "in silk attire," yet our own James the Sixth was forced to borrow a pair of silken hose from the Earl of Mar, that his state and bearing might be more effective in the presence of the ambassador of England,—"for ye would not, sure," said the royal pedant, "that your king should appear as a scrub before strangers."[1] King Henry the Eighth was the first of the English sovereigns who wore silk stockings.

Many caterpillars, in walking, fix the anterior feet on the plane of their position, and, bending their body upwards, they advance and fix their anal feet, assuming for a time the form of a loop. They then unfix their anterior hold, and stretching forward their bodies, proceed as it were by spanning the ground. They are hence called surveyors (*arpenteuses*) by the French naturalists. Others, known under the name of *Batons*, fix themselves, in repose, to twigs and branches by their hinder feet, and thus hold themselves out stiff and immoveable for many successive hours. It may easily be supposed that this extraordinary attitude must require the exercise of, comparatively speaking, most enormous strength. No vertebrated animal, not in a state of catalepsy, could sustain it even for a few seconds. We find accordingly (through the laborious investigations of a great interpreter of nature, Lyonnet) that even in the caterpillar of *Cossus ligniperda*, a species which lives in trees, but does not exercise itself in the way alluded to, there are above 4000 muscles. Many move along the ground rapidly by the successive motion of each segment, as if a wave were flowing over or pervading their bodies. The intestines of caterpillars consist of a large canal without inflections, the anterior portion being sometimes slightly separated in the form of a stomach, and the posterior forming a wrinkled cloaca. There are also four very long biliary vessels, usually inserted pretty far back.

The habits of caterpillars are very various in the different kinds. Although a great majority feed on vegetable substances, many of the smaller kinds are extremely destructive among stuffed birds, and all kinds of woollens. They will even devour leather, lard, wax, wafers, and all fatty matters. Many confine themselves to one particular substance, while others are polyphagous. Some unite in society, and form a silken tent to screen themselves from their natural enemies, and the extremes of heat and cold; others are independent and solitary. As they increase in size they cast their skins, and this process of sloughing generally takes place about four times. A great proportion, before assuming the chrysalis state, spin around them a web or cocoon, more or less compact according to their kind. In some (as in *Bombyx mori*, or the silk-worm) it is of a rich saffron colour, and of exquisite fineness; in others it is of a membranous texture, from being originally more compactly glutinous, instead of consisting of distinct threads. Many mingle with their funeral web or winding-sheet, particles of earth or decayed vegetable substances, which greatly increase the size of their cocoons. The chrysalids of the diurnal Lepidoptera are, however, naked or exposed, and are usually suspended by the posterior extremity, or fastened by a silken cord or girth around the middle of the body. They are also angular in their forms, while those of moths are rounded or cylindrical. In one or two of the crepuscular kinds, or Sphingides, the proboscis projects, and is encircled by a separate envelope, even in the chrysalis state. All the other parts are, however, swathed in a coriaceous covering, although the form of the wings and other members may be traced externally, in slight though distinct relief. The abdominal segments are capable of motion, like the "thews and sinews" of a warrior in plaited mail. The period of repose varies from a few weeks to one or two years. Such as assume the chrysalis state late in autumn, do not appear in the winged condition till the ensuing spring. Many remain in the egg state all winter; and such diurnal Lepidoptera as have two *flights* in the year are generally produced in the first place in spring from chrysalids which have lain torpid all winter, and become themselves the parents of another flight, which make their appearance at a later period of the same season. Thousands perish before attaining the perfect state, not only as the natural food of most passerine birds, but as the living bed of the Ichneumonides, which deposit their eggs in the fatty substance of the caterpillar, and thus by degrees deprive it of the source of life.

The observance of these and of other singularities, which we cannot here detail, will afford a never-failing source of interest to the student of nature's mysteries, and will assuredly yield an ampler and more enduring recompense than "Pyrrhos' maze or Epicurus' stye." In spite, however, of all that has been said and written of the wonders of entomology (and the subject, to be understood, must rather be seen than listened to, or even reflected on through the pages of the best instructed author), we fear that many continue to regard it with very inadequate notions. But how may not piety itself revolt at the thought of the most numerous works of an Almighty Creator's hand being regarded as trifling or unworthy of a deep and most reverential consideration. When Solomon, whose earthly glory never equalled the lustre of the "lilies of the field," desired us to ponder on a meet emblem of diligence and wisdom, it was not from what we consider as the most important parts of the creation that he drew his example:—"Go to the *ant*, thou sluggard; consider *her* ways, and be wise." So spake, and under a divine impulse, he who is himself emphatically called the "wisest of men." Yet in many a high-

[1] *Edinburgh Cabinet Library*, viii. p. 154.

Lepidoptera Diurna.

flown moral and (pseudo) religious declamation, folly and ignorance not seldom combine to illustrate whatever is mean, insignificant, or worthless, by a reference to some unfortunate form of insect life. Even the pious Newton (not Sir Isaac, but the author of *Cardiphonia*, whose name was John) somewhere likens the extremest act of thoughtlessness and folly to a person breaking off from some worldly and important presence to "pursue a butterfly." Did the excellent author forget, or never know, that a butterfly is not only in itself a creature of such exquisite beauty that neither the "sea of light," nor any other of the most famous gems which ever from the brow of an eastern tyrant dazzled the dark eye of a trembling slave, can compare with it in varied and gorgeous lustre;—or did he expunge from his recollection that the same divine hand which formed man after his own likeness, also created every other thing which breathes the breath of life, and that all were declared *good* when seen by that eye, before whose brightness even the angels veil their faces? Compared with the eternal interests of man, we admit that all earthly pursuits, including even the best and purest—those of science—are as dust in the balance; but, bearing in mind our higher destiny, and yet believing that as there are celestial bodies and bodies terrestrial, so we cannot be better occupied than in devoting a convenient season to study (without which we cannot understand) the works of God,—for "the glory of the celestial is one, and the glory of the terrestrial is another," and both, though differing from each other in brightness, co-exist in divinest harmony, simply because

The hand that made them is itself divine.

Therefore, though ourselves among the most loyal of liege subjects, we should not hesitate to pursue a butterfly, if wanting to our collection, "even in the presence of a crowned king." But this, we fear, is a digression.

In lepidopterous insects in the perfect state, we find a first lateral stomach or crop,—a second, inflated or turgid, —a small intestine, tolerably long,—and a cæcum near the cloaca.

The order is naturally divisible into three families, viz. Diurna, Crepuscularia, and Nocturna.

FAMILY I.—DIURNA.

The insects of this family, commonly called Butterflies, are never seen on the wing except during the day, and in a state of repose usually hold their wings erect. Their antennæ are capitated, or terminated by a club or knob, with a few exceptions, such as the splendid genus *Morpho*, in which they are almost filiform, and the Fabrician genus *Urania*, in which they become more slender towards their extremities. The caterpillars have always sixteen feet, and the chrysalids are naked and angular. These are the only lepidopterous insects in which we never find the exterior margin of the inferior wings presenting a rigid seta or bristle, for the retention of the superior pair.

The genus Papilio of Linnæus, divided into certain sections, contained the whole of that splendid and infinitely-varied tribe which we call Butterflies, of which the species are so numerous and diversified that naturalists soon felt the necessity of multiplying the genera, both because it was right so to do, and for the mere convenience of restricting the amount of species contained in each. In the later editions of the *Systema Naturæ*, Butterflies, or diurnal Lepidoptera, were divided into six phalanges. The first, called *Equites* (which now correspond to the true genus *Papilio*, as restricted by Latreille), was divided into *Troes* and *Achivi*, a division since ascertained to be rather unfortunate in some respects, in as far as it occasionally separates the males and females of the same species; the second was named *Heliconii;* the third *Parnassii;* the fourth *Danai*, subdivided into *Candidi* and *Festivi;* the fifth *Nymphales*, also subdivided into *Gemmati* and *Phalerati;* the sixth *Plebeii*, again divided into *Rurales* and *Urbicolæ*. Geoffroy (in his *Histoire abregée des Insectes*) follows the Linnæan system, and improves it chiefly by applying the principles previously established by Réaumur in his *Mémoires*. Degeer and Olivier likewise so far follow Linnæus as to retain the name *Papilio* as a generic term; but, in order to facilitate the labours of the student, they have introduced additional sections and subdivisions. The labours of Scopoli, as we have elsewhere observed,[1] are defective in relation to these insects, in consequence of his generic characters being drawn from the presence or absence of spots on the wings, and other distinctions which are of little or no value, except for the formation of artificial sections, or the discrimination of species. In the earlier works of Fabricius, scarcely any alterations were made in the arrangement of the Linnæan *Papiliones*. But in the *Entomologia Systematica* of that author, and still more in his *Systema Glossata* (left unfinished at the period of his death, a great number of genera were eventually created.[2] Latreille, in his numerous works, has constituted various generic groups, which appear to have been very generally adopted. Of the chief of these we shall speedily give account. Denis and Schiffermuller (in the *Catalogue des Lepidoptères de Vienne*) had previously benefited this branch of Entomology, by assuming the form and metamorphosis of the caterpillar as principal bases of their divisions; and Ochsenheimer has since successfully applied the same method to all the European species. Our ignorance of the history of the greater proportion of exotic groups has unfortunately retarded the more general application of the principles of an improved system, although Dr Horsfield's admirable *Lepidoptera Javanica* has done much to complete our knowledge of many fine Javanese species. Dumeril and Lamarck have also, each after his own manner, endeavoured to amend the classification of diurnal Lepidoptera; and in regard to pictorial works in this department, Clerk, Cramer, Engramelle, Hubner, Ernst, Esper, Stoll, Herbst, Jablonsky, Godart, and others, have published collections of coloured figures, some of which stand unrivalled in extent and magnificence by the most costly productions of those who have most successfully endeavoured to illustrate any of the kindred branches of natural science. Even in our own country, where natural history is so sparingly patronised, and so lightly valued, this beautiful branch of zoology has been rather sumptuously exhibited, and the names of Drury, Abbot, Wilkes, Shaw, Donovan, Lewin, Leach, Swainson, Stephens, Curtis, and Horsfield, will readily occur to the grateful recollection of the reader.

Indeed, on account of the exquisite beauty of their forms and colours, Butterflies have, from the earliest periods of natural history, greatly excited the zeal and admiration of collectors. They occur in all quarters of the world,—from the frozen shores of Greenland and Spitzbergen, to high southern latitudes; but the tropical regions of Asia and America are the most productive of large and splendidly-coloured species.

[1] *Illustrations of Zoology*, letter-press preceding plate xxviii.

[2] Illiger has given an extract from the last-named work, in his *Magazin;* and the English reader will find it exhibited by J. G. Children, Esq. in the *Phil. Mag. and Annals* for February 1830.

M. Latreille divides the Linnæan Papiliones into two sections.

Section 1st,

Contains all those butterflies which have but a single pair of spurs or spines to their tibiæ, and placed at the posterior extremity of these parts. When in a state of repose they raise their wings perpendicularly, joining them at the tips. Their antennæ are usually clubbed or inflated at the extremity, sometimes almost filiform. In this section are included the genus Papilio and the Hesperiæ *ruricolæ* of Fabricius. It is itself divisible as follows.

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Third joint of the inferior palpi sometimes almost wanting, sometimes very distinct, but equally well clothed with scales as that which precedes it. Hooks of the tarsi apparent or projecting.

Some of the genera of this subdivision are hexapod or six-footed, that is, all the feet are formed for walking, and are almost identical in both sexes. Their chrysalids, in addition to the common attachment by the posterior extremity, are fixed by the passing of a silken thread across the body. A few are enclosed in a rude cocoon. The central cell of the lower wing is closed inferiorly.

In Papilio (proper) of Latrelle (Plate CCXLVI. fig. 2), the inferior palpi are extremely short, scarcely reaching the clypeus with their upper extremity; their third joint is indistinct. The species of this genus are remarkable both for elegance of shape and beauty of colouring. Those spotted with red on the breast form the division of *Eguites Troes* of Linn.; those destitute of such marks he styled *Achivi* or Greeks. They abound in the tropical countries of both hemispheres, but are rare in more northern countries. Indeed we are not aware that more than three exist in Europe, viz. *P. Machaon*, *Podalirius*, and *Alexanor*, of which the first is a well-known native of some of the southern counties of England. The caterpillars of this genus are naked, and when alarmed protrude from the superior part of the neck a soft forked horn, that usually diffuses a penetrating and unpleasant odour. The chrysalis is exposed, and is supported by means of a silken band. In the genus Parnassius of Lat. (*Doritis*, Fab.), Plate CCXLVI. figure 3, the inferior palpi evidently extend above the clypeus, taper to a point, and are distinctly triarticulated. The terminal button of the antennæ is short, almost ovoid and straight. The females are provided with a kind of corneous boat-shaped sack at the posterior extremity of the abdomen. The species of this interesting genus seem peculiar to the alpine or subalpine countries of Europe and the north of Asià. Their caterpillars possess a retractile tentaculum, like those of the preceding genus; but they form, prior to their transformation, a cocoon of leaves united by filaments of silk. The species which we have figured in the present work is a noted Swiss insect, *P. Apollo*. It inhabits alpine valleys. It is said, however, to occur on plains near Upsal, and other northern countries. In the genus Thais of Fab. (Plate CCXLVI. figure 5), the palpi resemble those of the preceding, but the terminal button of the antennæ is elongated and curved, and there is no corneous pouch at the extremity of the abdomen of the female. The species are characteristic of the south of Europe. A few occur on mountains. In the preceding genera the internal margin of the under wings is concave or folded. In the two following the inferior wings project beneath the abdomen, and form a canal for its reception. The caterpillars, many of which feed on the Cruciferæ, have no tentaculum. The species correspond to the *Danai candidi* of Linn. and include all our common white Butterflies. In Pieris, Lat. (*Pontia* of Fabricius and of the English entomologists), Plate CCXLVI. figure 6, the inferior palpi are almost cylindrical and slightly compressed, with the last articulation at least almost as long as the preceding. The club of the antennæ is ovoid. We have nine or ten British species, including what are usually called cabbage-butterflies, such as *P. brassicæ*, *napi*, &c.; also the more richly attired Orange Tip, or Lady of the Woods, *P. cardamines*.[1] Mr Stephens confines the generic title of *Pieris* to the hawthorn butterfly, *P. cratægi*, a species as yet unknown in Scotland. In the genus Colias of Fab. (Plate CCXLVI. fig. 4), the club of the antennæ forms an elongated and reversed cone, and the inferior palpi are greatly compressed, with the last joint much shorter than that which precedes it. The indigenous species are in general more warmly coloured than those of the preceding genus.

Other genera of this subdivision (*Tetrapoda*) have the anterior pair of feet much shorter than the others, folded on the breast, and unfit for walking; sometimes in both sexes, sometimes only in the males. The chrysalis is simply attached by its posterior extremity, and hangs with its head downwards. The genus Danais (*Euplœa*, Fab.), part of the *Danai festivi* of Linn. (Plate CCXLVI. figure 4), are distinguished by their triangular wings, and antennæ terminated by a kind of elongated and curved button. In Idea, Fab. the wings are almost oval and elongated, and the antennæ nearly filiform. In Heliconius, Lat. (*P. Heliconii*, Linn.) (Plate CCXLVI. figure 7), the antennæ are twice the length of the head and thorax, and increase insensibly towards the extremity. In Acræa, Fab. the antennæ are shorter, and terminate in a more abrupt button. Those in which the inferior palpi are but slightly compressed, distant throughout their length, or at least at their extremity, and terminated abruptly by a slender and acicular joint, and in which the under surface of the wings is frequently ornamented by silvery spots, or by yellow ones upon a fulvous ground, form the genera Cetosia and Argynnis (Plate CCXLVII. fig. 2) of Fabricius and Latreille. The caterpillars (ibid. fig. 3) are beset with spines or tubercles. In the former, of which several species have the wings elevated and elongated, the inferior palpi are distant throughout their entire length, the hooks of the tarsi are simple, and the club of the antennæ oblong. In the latter the club is short and abrupt, the hooks of the tarsi are unidentated, and the inferior palpi are distant only at their extremity. The inferior wings are often rounded. These butterflies are remarkable for the silvery spots upon their under surface. They are called *Fritillaries* by the English collectors. There are four or five indigenous species. The caterpillars have a pair of spines upon the neck, longer than the rest. Such as fall under the genus *Melitæa* of Fab. have yellow spots on the under surface, and the general markings above are more disposed in squares, like a chess-board. In *M. Seleni* and *Euphrosyne*, however, the upper surface is very similar to that of the preceding species, and there is an appearance of pearly or silvery lustre on the under surface of the lower wings. Latreille, we think wisely, unites the whole under the genus Argynnis.

In the five following genera the inferior palpi are contiguous in their whole length, terminate gradually in a point, and are much compressed. The genus Vanessa (Plate CCXLVI. fig. 9, and CCXLVII. fig. 1) differs from the others in the antennæ, which are terminated abruptly by a short turbinated or ovoid button. The caterpillars are densely spinous (Plate CCXLVI. fig. 10). Here is placed the common tortoise-shell (known in Scotland as the

[1] For the indigenous species, see *Naturalist's Magazine*, vol. ii. p. 224.

Devil's Butterfly), *V. urticæ*, and several other British species, such as the Camberwell Beauty, *V. Antiopa*, and the Peacock Eye, *V. Io* (ibid. fig. 9). The Painted Lady, *V. cardui*, remarkable for the vast extent of its geographical distribution, being fully more widely dispersed than any other form of animal life with which we are acquainted, belongs to our present genus. It is, however, placed in the genus Cynthia by Mr Stephens. In the four following genera the antennæ terminate in an elongated club, or are almost filiform. In Libythia of Fab. the males alone have the anterior pair of feet extremely short, and tippet-like. The inferior palpi project observably in the manner of a beak. The upper wings are very angular. In Biblis, Fab. the palpi are also longer than the head, but more obtuse, and curved a little at their extremity. The anterior legs are abbreviated in both sexes, and the antennæ terminate in a much smaller club. The nerves of the superior wings seem strongly inflated at their origin. In Nymphalis, Lat. (Plate CCXLVII. figs. 5, 7, 9), the legs resemble those of the preceding, but the inferior palpi are shorter. The club of the antennæ is more elongated than in Vanessa, from which they are not strongly distinguished. Their caterpillars are, however, different (ibid. fig. 4), being less spiny, and more elongated towards the posterior extremity, which is slightly forked. The species of this genus (of which, as a British example, we may name the Purple Emperor, placed in the genus Apatura by Mr Stephens) are frequently ornamented by brilliant and varied colours, and, when in prime condition, are highly prized by collectors. They are distinguished by the strength and thickness of their wings, which enable them to exercise a smooth, powerful, and sustained flight. Their motions are consequently not of that zigzag nature observable in many species, but steady and continuous, like the soaring of a bird of prey. They frequently haunt the summits of forest trees, and other elevated stations, and are therefore difficult to capture. This disadvantage, however, is to a certain extent obviated by the boldness of their disposition; for, when their situation is accessible, they are not deterred by an unsuccessful attack from settling again on the spot where they were first observed. The European species, such as the Purple Emperor above named (*N. Iris*), are taken by means of bag-nets, fixed to poles thirty feet high. They are said to be attracted by the odour of acrid or fermenting substances, and such are sometimes used by entomologists to induce them to descend from their inaccessible positions. The genus is very extensive. M. Godart[1] describes 267 different kinds. *Nymphalis Jasius*, the species which we have selected for illustration on the plate last referred to (figs. 7 and 9), is one of the most beautiful of European insects. We received it from M. Case-Nuove of Lyons. The genus Morpho, Fab. (Plate CCXLVII. fig. 8), differs from Nymphalis in its almost filiform antennæ, which are feebly and insensibly enlarged towards the extremities, but not clubbed. All the species are peculiar to South America, and are well deserving the special attention of those who desire to form a just notion of the splendour and magnificence of many lepidopterous insects. We could describe them with great pleasure did our limits admit of such details. M. Godart has separated, under the name of Pavonia (ibid. fig. 10), certain species, of which the central cell of the lower wings is closed, and the most internal nerve of the upper pair is curved in the form of the letter S, in place of being straight or slightly arched. A species found in the East Indies, of which the lower wings are prolonged into a tail (*P. Phidippus*), forms the type of the genus Amathusia of Fabricius. We have figured the larva and chrysalis on Pl. CCXLVIII. figs. 1 and 8. All the rest belong to the new world. Those which follow have also the discoidal cell of the lower wings closed posteriorly. Such are Brassolis, Fab. (ibid. fig. 3), Eumenia, Godart (do. fig. 5), Eurybia, Illiger (do. fig. 10), and Satyrus, Lat. (do. fig. 6). The caterpillars of the last-named genus are naked, or nearly so, and the posterior extremity of their body is narrowed into a furcated point. The chrysalids are bifid anteriorly, and their back is tuberculated.

* *

Inferior palpi with three distinct joints, of which the third is almost naked, or much less thickly covered with scales than the preceding ones. The hooks of the tarsi are very small, and scarcely if at all projecting. The discoidal cell of the posterior wings is open posteriorly.

The caterpillars of this subdivision are oval, or resemble *Onisci* in their forms. The chrysalids are short, contracted, smooth, and always fixed, like the genus Papilio properly so called, by a silken thread across their bodies. These butterflies were classed by Linnæus among his *Plebei*, in the division of *Ruricolæ*, and Fabricius placed them in a corresponding section of his *Hesperiæ*. They form the genus Argus of M. Lamarck, and contain, among other species, all our beautiful little *Blues*, which in bright summer days so enliven our grassy downs, and almost all other spots of open sunshine.

Sometimes the antennæ terminate, as usual, in a small and solid button-like inflation. In the genus Erycina, Lat. (Pl. CCXLVIII. figs. 2 and 4), the anterior pair of feet are much shorter than the others, at least in the males. They belong to America. In the rest all the legs are alike in both sexes. In Myrina of Fab. (ibid. fig. 11) the inferior palpi are long and projecting. In Polyommatus (ibid. fig. 12) the palpi do not extend much beyond the epistoma. These beautiful little insects receive their name from the number of small eye-like spots with which their under surface is ornamented. We have a considerable amount of indigenous species, most of which are blue above, the females of some being brown. In the Scotch Argus (*P. Artaxerxes*), so common near Edinburgh in June and July, at the base of Arthur's Seat, above the line of the Railway, both sexes are blackish-brown above, with a variable white spot on the disk of the upper wings, and some lunated red spots, more or less distinct, on the under. The splendid little butterflies called *Coppers* are placed by our collectors in the genus Lycæna of Fabricius.

A few Lepidoptera of our present subdivision are remarkable for the peculiar form of their antennæ. Those of one of the sexes of the genus Barbicornis, Godart, are setaceous and plumy,—those of Zephyrius, Dalman (Pl. CCXLVIII. fig. 7), are terminated by ten or twelve globular joints, separated like the beads of a rosary.

Section 2d.

The second section of diurnal Lepidoptera contains those species of which the posterior tibiæ are furnished with two pair of spines, viz. a pair at their extremity, and another above. The lower wings are usually retained in a horizontal position, even when the insect is at rest, and the extremity of the antennæ very often forms a distinctly hooked point. Their caterpillars, judging from the few with which we are acquainted, bend together the leaves of plants for a protecting covering, and spin within that leafy

[1] *Encyclopédie Méthodique*, art. *Papillon*.

Lepidoptera Crepuscularia.

chamber an extremely thin cocoon of silk, in which they are transformed into chrysalids. The latter are smooth, and without angular elevations. These Lepidoptera form the *Plebei Urbicolæ* of Linnæus, with the addition, by Latreille, of those rare and splendid insects placed by Fabricius in the genus URANIA.

The former belong to the genus HESPERIA of Fab. (Pl. CCXLVIII. fig. 13), and are characterized by the distinctly clavate termination of the antennæ, and by the inferior palpi being short, broad, and thickly covered anteriorly with scales. Here are placed *H. alveolus*, *malvæ*, and *tages* (for chrysalis and larva see fig. 15), among the British species. In the genus URANIA of Fab. just alluded to (ibid. figs. 9 and 14), the antennæ, at first filiform, become attenuated or setaceous at the extremity, and the inferior palpi are slender and elongated, with the second article greatly compressed, and the last much more attenuated, almost cylindrical, and naked. "The butterflies," says Mr Swainson, "comprising this remarkable genus, are perhaps the most splendid insects in creation. No art can effectually represent the changeable and resplendent green which relieves the velvet black of the wings, and which varies with every change of light. The typical species are found in Tropical America, where they fly with amazing rapidity, and perform, like their prototypes the swallows, annual migrations. When at rest, the anterior wings are flat or horizontal, but only slightly spread."[1] *U. Leilus* is found in Surinam, and is figured in Madame Merian's work on the insects of that country. *U. Ripheus* of Cramer (*Leilus Orientalis*, Swainson) was originally figured from a specimen taken at Chandernagor, in Bengal, and belonged to the rich cabinet of M. Gigot d'Orcy. We perceive, however, the following notice of its locality in a recent work: "Cette espèce, que l'on peut considerer comme le plus beau Lépidoptère connu, habite *Madagascar*. Elle a été prise une seule fois à Bourbon, où la chenille avoit peut-etre transportée accidentellement."[2] The synonymy of this exquisite insect has been greatly embroiled on account of Cramer supposing the species represented by his figure, which has six tails, to be identical with Drury's, which has none. Mr Swainson has shown that the latter insect, having clavated instead of filiform antennæ, is not only specifically distinct, but pertains to a different genus. He has named it *Rhipheus dasycephalus*.[3] In the *Nouv. Ann.* quoted below, the reader will find an account of the larva of *U. rhipheus*, which, in common with the caterpillars of the other species, has been hitherto unknown to naturalists. Mr Swainson has represented, with his usual elegance and accuracy, almost all the known species of these rare and beautiful insects. That which we have figured in illustration of our present article is a new species (*U. Boisduvalii*), lately published by M. Guerin.[4]

FAMILY II.—CREPUSCULARIA.

The most prominent species of this family are known by the name of Sphinxes or Hawk-moths. They are furnished with a spine or strong bristle on the anterior margin of the inferior wings, which being received by a process of the under surface of the superior pair, maintains them in a horizontal or somewhat inclined position in repose.[5] The character just mentioned is indeed perceptible also among the nocturnal tribes; but our present family is distinguished by the antennæ, which are prismatic or fusiform, usually thickest in the middle. These insects fly with great strength and celerity, owing to the extent and firm consistence of their wings, the powerful muscles by which they are moved, and the bird-like manner in which their taper bodies are poised. From their name, we would naturally infer that they are observed chiefly during the morning and evening twilight; but many species may be seen darting from flower to flower even at mid-day. As their capture is difficult, and their rearing from the caterpillar precarious, they are in general highly prized by collectors. In the larva state they have always sixteen feet. The chrysalis is cylindrical, blunt-headed, with a conical abdomen, and destitute of those points or angular prominences observable in so many of the diurnal Lepidoptera. They are usually enclosed in a cocoon, or concealed either in the earth or under some protecting body. They are supposed to derive the name of *Sphinx* from the peculiar attitude assumed by several of their caterpillars, which in some respects bear a resemblance to the fabled monster of antiquity. A few produce a humming sound. Latreille divides the family into four sections, which, in corresponding order, answer to the genera *Castnia* and *Sphinx* of Fabricius, and to those which he at first named *Sesia* and *Zygæna*.

The first section, named HESPERI-SPHINGES, is composed of those species which connect the Hesperides of the preceding family with the Sphinges properly so called. The antennæ are always simple, thickened towards the middle, or at the extremity, which forms a hook, narrowed to a point, without any tuft of scales, at the end. They are all furnished with a distinct proboscis, and the inferior palpi are composed of three very apparent joints.

In the genus AGARISTA, Leach (Plate CCXLIX. fig. 1), the inferior palpi are elongated, with the second joint strongly compressed, and the last slender and almost naked; the antennæ are simple, gradually thickened towards the middle, and then becoming attenuated, terminate in an elongated hook. In the genus CORONIS, Lat. (ibid. fig. 2), the club of the antennæ is more developed. In the genus CASTNIA of Fabricius (ibid. fig. 3), all of which are from the new world, the antennæ resemble those of Agarista; but the palpi are shorter, broad, and cylindrical.

The second section, named SPHINGIDES, have the antennæ always terminated by a little flake of scales; the inferior palpi are broad, or transversely compressed, thickly clothed with scales, and the third article generally indistinct. Most of the caterpillars have a smooth body, elongated, thickest towards the posterior extremity, which is furnished with a horn, the sides obliquely or longitudinally striped. They feed on leaves, and undergo their metamorphoses under ground, without spinning a cocoon. Many seem, however, to form a little vaulted chamber, with agglutinated walls, which protects them from the circumjacent earth. Here are arranged many fine insects belonging to the genus SPHINX properly so called (Plate CCXLIX. figs. 5 and 6), of which the antennæ, from about their centre, form a kind of prismatic mass, either simply ciliated, or transversely striated on one side, in the manner of a rasp. The trunk is very distinct. These insects fly with great velocity, sometimes giving utterance to a humming noise, occasioned no doubt by the rapid vibration of their wings. Instead of settling upon flowers like bees and other insects, they are frequently observed merely to hover over or before them, and to extend their long tubular trunks towards the nectaries. This peculiar motion has probably obtained for

[1] *Zoological Illustrations*, second series, fol. 125.
[2] *Nouvelles Annales du Muséum d'Hist. Nat.* t. ii. p. 261.
[3] *Zoological Illustrations*, second series, plate 131.
[4] *Iconographie du Règne Animal*, pl. 82 (*Insectes*).
[5] This character, according to M. Godart, is wanting in some species of the genus *Smerinthus*.

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them the appellation *hawk-moths*. *S. Atropos*, commonly called the death's-head moth, is one of the finest of the European species. When seized it sometimes utters a shrill cry, caused, according to Réaumur, by the friction of the palpi on the trunk,—in the opinion of M. Lorey, by the escape of air from two cavities in the abdomen. It makes its appearance in the perfect state during autumn. The caterpillar, at least in Britain, feeds voraciously on potato-leaves. It is difficult to rear beyond the chrysalis state. We had six specimens alive at one time during the summer of 1826, all of which entombed themselves after a time beneath the earth, but never made their appearance in the perfect state. On being examined after the lapse of ten or twelve months, they were found lying some inches below the surface, in the state of chrysalis, each in an egg-shaped hollow, formed by the caterpillar. They were quite light and stiff, and of course dead and unproductive of the desired *Imago*. The death's-head moth, in common with several others of the genus, is very widely distributed. We have received it from Africa and the East Indies; and M. Boisduval informs us that it is well known in the Isle of France. The natives of the latter country believe that the dust which it casts from its wings in flying through an apartment, is productive of blindness to the visual organs on which it falls. It is difficult to trace the origin of this fable, recorded by St Pierre in his Voyage to the Isle of France. We have many other native species, which we cannot here enumerate.[1] One of the rarest and most beautiful of the European species, *Sphinx Nerii* (genus *Deilephila*, Ochs.), occurs in Madagascar and the Mauritius. It likewise inhabits Asia Minor, Bengal, and the whole of Africa. We received it from the vicinity of Genoa. It has recently been captured in England.

Other genera of the Sphingides have the abdomen terminated by a broad tuft of scales. Such is our humming-bird hawk-moth, *Macroglossa Stellatarum*, Ochs. Some nearly allied species, to which Fabricius latterly applied the generic name of *Sesia* (such as *S. fusiformis*, *Bombyliformis*, &c.), are distinguished by the clear consistence of the greater portion of their wings. In the genus Smerinthus of Lat. (Plate CCXLIX. fig. 11), the antennæ are toothed or serrated.

The third section, named Sesiades by Latreille, contains those species of which the antennæ are always simple, fusiform, and elongated, and frequently terminated, as in the preceding genera, by a little bundle of scales; the inferior palpi are narrow, slender, and distinctly triarticulate, the last tapering to a point. The posterior legs are furnished with very strong spurs. The abdomen is generally terminated by a kind of brush. The caterpillars live by gnawing the interior of the stalks and roots of plants, like those of the nocturnal kinds (such as *Hepialus* and *Cossus*); they are naked, have no posterior horn, and construct, with the debris of the substances on which they are nourished, a cocoon, in which they undergo their final metamorphoses.

In the genus Sesia of Latreille (*Ægeria*, Fab. Plate CCXLIX. figs. 7, 12, and 13), the antennæ terminate in a little tuft of scales. The wings are horizontal, and composed of clearer vitreous portions, interrupted by darker coloured veins. The posterior extremity of the body is brush-like. Several species exhibit to a casual observer rather the appearance of wasps or flies, than of lepidopterous insects. The genus Thyris of Hoffmansegg (ibid. fig. 8) resembles Sesia; but the antennæ are more slender, almost setaceous, and without any terminal tuft. The wings are angular and indented. The abdomen terminates in a point. In Ægocera of Lat. (ibid. fig. 9), the antennæ also want the tuft, but they are evidently thickened towards the middle, and fusiform; the second joint of the inferior palpi is furnished with a bundle of hairs, which project in a beak-like fashion. The abdomen likewise terminates in a simple point. The wings are inclined, and entirely covered with scales.

Lepidoptera Nocturna.

The fourth and final section of our present family is that of the Zygænides. It consists of Lepidoptera in which the antennæ, always terminated by a point destitute of a tuft, are sometimes simple in both sexes, fusiform, or resembling the horn of a ram, sometimes thickened towards the middle, almost setaceous, pectinated in both sexes, or at least in the males; the inferior palpi of medium size, or small, nearly cylindrical, and always formed of three distinct articulations. The wings, when at rest, are inclined; that is, sloped down laterally like the roof of a house, and present vitreous spots in many species. The abdomen is not brush-like at the extremity. The spurs of the posterior legs are usually small. The larvæ of these insects live exposed on various Leguminosæ, and other plants. They are short, inflated about the middle, and attenuated towards either end. Their bodies are smooth, or but slightly haired. In the course of their transformations they spin a pretty solid and coriaceous cocoon, attached to the stalk of a plant. The perfect insect issues from the chrysalis in a few weeks. The flight is somewhat heavy, and both sexes may frequently be taken together, reposing on the plants on which the female lays her eggs.

In the genus Zygæna of Lat. (Plate CCXLIX. figs. 4 and 10), which appears to be as yet unknown in the new world, the antennæ are simple in both sexes, and terminate abruptly in a fusiform mass, or one like a ram's horn. The inferior palpi rise above the clypeus, and are pointed at the end. This genus contains the Burnet moths of the English collectors, of which *L. loti* and *filipendulæ* are well-known examples. The genus Syntomis of Illiger differs from Zygæna chiefly in the antennæ, which are not so thick, but slender, or insensibly fusiform. The inferior palpi are short and obtuse. In the genus Atychia of Hoffm. (ibid. fig. 16), the antennæ are simple in the females, and bipectinated in the males. The inferior palpi are very hairy, and extend obviously beyond the clypeus. The wings are short. The spurs at the extremity of the posterior legs are strong. The genus Procris of Lat. (ibid. fig. 17) approaches the preceding so far as respects the antennæ, but the inferior palpi are shorter and less hairy. An ornamental insect, the *Sphinx Statices* of Linn. affords a good example of this genus. It is called the green forester by Harris, and forms with another species the genus *Ino* of Leach and Stephens. Other Lepidoptera of this section have the antennæ in both sexes bipectinated, or furnished with a double row of elongated teeth. Such of them as have a distinct trunk form the genus Glaucopis of Fab. (ibid. fig. 18)—those in which that organ is wanting or indistinct compose the genus Aglaope (ibid. fig. 15).

FAMILY III.—NOCTURNA.

The vast assemblage of species of which this great division is composed, are known under the familiar name of Moths, and correspond to the old and undivided genus *Phalæna* of Linnæus. Their wings, with a few exceptions,

[1] Mr Rennie's *Conspectus of the Butterflies and Moths found in Britain* will prove useful to those who cannot obtain access to the rarer or more costly works from which it is compiled.

are *bridled*, in repose, by means of a bundle of setæ, or the corneous bristle before mentioned in our generalities of the preceding family. Their position is either horizontal or inclined; sometimes they embrace the sides and upper surface of the abdomen. The antennæ are setaceous, or become gradually narrower towards the extremity. They are frequently feathered or pectinated, especially in the males, and are usually more ample in that sex than in the females. The legs of the larvæ vary from ten to sixteen in number. In certain species both sexes seem to want the tongue; and the females of a few have no wings, or but the merest rudiments of those organs. The chrysalids are always rounded, or without angular points.

These insects, as their family name imports, are seldom seen on the wing till after sunset. They continue their flight, throughout the mild and dewy nights of summer, till the morning twilight. During the brightness of the day season they conceal themselves in tangled vegetation, on the shady side of walls and buildings, on the under side of large leaves, or in the crevices of the gnarled bark of ancient forest-trees, and other sombre places. So astounded indeed are the greater number by the "garish eye of day," that when discovered by the sharp-sighted entomologist, they allow themselves to be taken prisoner without an effort to escape. A few, however, present exceptions to the general rule. Such, for example, are the males of *Bombyx zigzag*, which fly throughout the whole day, and fear not the brightest beams of "glorious Apollo." This same species presents a remarkable confirmation of what we have formerly stated, in the introductory portion of the present article, regarding the sense of smell in insects. The female of the moth just named is extremely sluggish, and seems seldom, if ever, to use her wings. When placed at an open window or elsewhere in an observable position, she will be speedily seen to receive the visits of the males, which fly swiftly towards her from all directions, undoubtedly guided by the sense of smell.

The classification of this family presents great difficulties to the entomologist in the way of a natural division into sections and sub-genera, and to it applies with peculiar force an observation made by Latreille regarding the entire order,—*Lepidopterorum ordo Entomologorum Scopulus.* In fact, the parts of the mouth, from the complex and greatly varied, yet clearly defined structure of which, in the masticating insects, so many excellent and available characters have been deduced, are among the lepidopterous tribes in general restricted in number, simple in form, and very similar in composition. The antennæ, too, especially among the nocturnal tribes, become rather sexual than generic distinctions;—and as the metamorphosis and general habits and history of many of the exotic species, which form the finest features in the richly stored cabinets of Europe, are almost entirely unknown, recourse cannot be had to such excellent and indeed indispensable aids towards a more natural and consistent classification. An accurate, perspicuous, and philosophical arrangement of the Lepidoptera, is therefore still a desideratum in our science.

Latreille, in his latest work (*Règne Animal*, second edition), divides the nocturnal Lepidoptera into *ten* sections. The species of which the wings are entire, or without fissures or digitations, compose the first nine. All those which, under the form of larva, live almost entirely exposed, or in fixed retreats, and of which many have less than sixteen feet, and which in their perfect state are characterized by very small or concealed upper palpi, more or less triangular wings, horizontal or decumbent, and not folding around the body, compose the first eight. The eighth itself is the only one of which the caterpillars have fourteen feet, of which two are anal. If in certain others the same number exists, the anal are wanting.

The first four sections correspond to the divisions *Attacus* and *Bombyx* of the genus Phalæna of Linnæus. The trunk is usually rudimentary or very small, and its two filaments are not united. The inferior palpi, with a few exceptions, are small and almost cylindrical. The antennæ, at least in the males, are pectinated or serrated. The wings are horizontal or decumbent, and in several the lower project, in a state of repose, beyond the upper pair. In some, also, the buckle-like process formerly mentioned as fixing the wings together, is here wanting. The thorax is smooth or uniform, as well as the abdomen, and woolly. The latter portion is for the greater part very voluminous in the females. The cocoon of the chrysalis is generally what may be called well *felted*, and of pretty solid consistence. Although the Nocturna of Latreille's fourth section (*Aposura*) bear a close relation to those which precede them, their caterpillars nevertheless offer a character unique and unexampled in the lepidopterous order,—the absence of the anal feet. We shall here give a brief sketch of the general characters of the nocturnal tribes, in accordance with the system of Latreille.

Section 1st, Hepialites.

We may here name as types the genera *Hepialus* and *Cossus* of Fabricius. The caterpillars are rarely met with, as they conceal themselves in the interior of the plants on which they feed. The cocoons which they form are composed in great part of particles of those same plants. The edges of the abdominal rings or segments of the chrysalis are toothed or spinous. The antennæ of the perfect insect are always short, and most generally present only one kind of small, short, rounded, and close-set teeth. Those of some others terminate always in a simple thread, but are furnished inferiorly in the males with a double row of barbs. The trunk is always very short, and not very obvious. The wings are decumbent, and generally elongated. The last rings of the abdomen in the female form a kind of oviduct or tail. In the larva state these insects are very destructive to trees, edible plants, and other useful products of the vegetable kingdom.

Sometimes the antennæ, almost conformable in both sexes, have only very short teeth disposed in one or two rows. Such are the three following genera. In Hepialus of Fab. the antennæ are almost granular, and much shorter than the thorax. The under wings are usually destitute of the curb or spine. The caterpillars dwell in the earth, and gnaw the roots of plants (Plate CCXLIX. fig. 27). A very abundant species, called the Ghost-moth, *H. humuli*, Fab., is characterized by the upper wings of the males being of a silvery white, without spots,—those of the female reddish yellow, with spots of a deeper hue. The larva is extremely destructive to hops, and also exists in great quantities in districts where that useful plant is unknown. It is often seen hovering over churchyards with a short pendulous motion to and fro, and is also frequently observed in pasture-fields, and plots of grass in garden grounds. In the genus Cossus of Fab. (ibid. fig. 14), the antennæ are at least as long as the thorax, and present on their inner side a range of small lamellar teeth, short and rounded at the end. The caterpillars live in the interior of trees, and make use of the saw-dust produced by the action of their mandibles in the formation of their cocoons. The chrysalids advance by a peculiar and instinctive motion to the external apertures of their ligneous dwellings, just at the moment of their final development, when their wings are about to expand. We doubt not that the little spinous projections with which the sides of the abdomen are armed, aid them greatly in that progressive motion. A wriggling movement would naturally produce an advance upwards or forwards,

Lepidoptera Nocturna.

but retreat would be impossible. The *Cossus ligniperda* is a noted example of the genus. In the larva state (ibid. fig. 19) it is extremely destructive to elm trees, which it perforates almost to the core, and by degrees produces first an unhealthy condition, rendered visible by a peculiar colour of the leaves, and finally decay and death. In the company of an honoured friend, the Rev. John Fleming of Rairigg, Windermere, we lately witnessed the hewing down of an old elm tree, which had braved the blasts of many stern winters, but had evidently become paralysed in its vital functions by the inroads of some insidious foe. By accident the large scaly head of a caterpillar was one day seen protruding from the rugged bark; and some other circumstances led to the belief that the tree was infested. To ascertain the cause of the disease with certainty, and to stay if possible its progress through the neighbouring groves, the sylvan monarch was consigned to the tender mercies of the woodmen of Bowness; and on being felled and hewn in different parts, we discovered several dozens of very large caterpillars of *Cossus ligniperda*, chiefly in the thickest part of the tree, a few feet above the ground, and several inches within the bark. They gave out, as we extracted them, a very peculiar odour, of an oily nature, and sufficiently repelling, we should suppose, to render it improbable that these larvæ were eaten by the ancients. It is however a well-received opinion, that the *Cossus* described by Pliny, and regarded by the Romans as a most delicious fare, was the caterpillar in question. It is frequently found in the willow as well as in the elm, and may possibly extend its ravages to the oak, the nidus assigned by Pliny to his edible worm. The latter, however, was most likely the larva of *Prionus coriarius*, or some other of the larger long-horned beetles; the more especially as we know from Madame Merian and other writers, that the grub of a congener, *Cerambyx damicornis*, is eaten in Surinam and the West Indies, both by slaves and freemen. The perfect insect of the *Cossus ligniperda* is of an ashy grey, with numerous small black lines on the upper wings. The posterior extremity of the thorax is yellowish, with a black line. We forgot to mention, that the oily odour of the caterpillar is by some considered to proceed from a reservoir of a peculiar fluid which the insect disgorges, for the purpose, it is believed, of softening the timber on which it feeds, and in which, as it increases in size, it perforates its hidden chambers. It is also remarkable as having afforded the subject of an extraordinary anatomical investigation by Lyonnet, detailed in his famous *Traité Anatomique de la Chenille du Saule*. The enthusiasm of a French writer has induced him, while lauding the merits of that signal publication, to allude to its subject-matter under the dignifying appellation of "the immortal worm!" The reader may satisfy his curiosity as to its external aspect, by inspecting the 19th figure of our 236th plate. On the same plate, fig. 14, we have represented the winged state of an American species, *C. Macmurtrei* of Boisduval. The genus Stygia of Draparnaud (ibid. fig. 24), placed by some writers among the *Zygænides*, is ranked by Latreille where we now introduce it. The antennæ have a double row throughout their whole length, of small, short, straight teeth, dilated and rounded at the end.[1]

Sometimes (and this character distinguishes the following genus from those enumerated in the preceding paragraph) the antennæ differ greatly in the sexes; those of the males being furnished inferiorly with a double row of barbs, and terminated by a filament; those of the females being entirely simple, but cottony at the base. Such are the species of the genus Zeuzera of Lat. (Plate CCXLIX. fig. 20), of which *Z. æsculi* is a beautiful indigenous example. Its larva dwells in the interior of the sweet chesnut tree, and in that of pear and apple trees. The body of the perfect insect is of a beautiful white, with blue rings on the abdomen, and numerous little spots of the same colour on the upper wings. It is not a common species.

Section 2d, Bombycites.

This section may be distinguished, both from that which precedes and that which follows it, by the following characters: The trunk is always very short, and merely rudimentary; the wings are either extended and horizontal, or decumbent, but the inferior wings extend laterally beyond the upper ones; the antennæ of the males are pectinated.

The caterpillars live exposed, and devour the more tender parts of vegetables. They usually spin a cocoon of pure silk. The chrysalids have no spiny processes or dentations on the edges of the rings of the abdomen.

The species with horizontal and extended wings (the Phalænæ Attaci of Linn.) form the genus Saturnia of Schrank (Plate CCXLIX. fig. 25), with which Latreille combines Aglia (*Bombyx tau*) of Ochsenheimer. It comprehends many magnificent species, such as *S. atlas* of China, called *porte-miroir* by the French, on account of the transparent or vitreous portions of the wings. *S. luna*, of a fine and delicate green colour, is an American species, remarkable for the extended tail-like appendages of the under wings.[2] The cocoons of two other species of this division, *Bombyx mylitta* of Fab. and *Phalæna cynthia* of Drury, have been employed for their silk from time immemorial in Bengal. The first of these species appears to be identical with the *Ph. paphia* of Dr Roxburgh. It occurs in great abundance in Bengal, and in many parts of the adjoining country, and affords a plentiful supply of a very durable though coarse and dark-coloured silk called *Tusseh*, much used by the Brahmins and other sects of Hindoos. This species cannot be domesticated; but the hill people go into the jungles, and when they perceive the dung of the caterpillars under a tree, they immediately search for them among the branches, and carry off whatever they require. These they distribute on the asseen trees (*Terminalia alata glabrata* of Roxb.), and as long as they continue in the caterpillar state, the Pariahs guard them from birds by day and from bats by night. The natural food of this species is the *Byer* tree of the Hindoos, called *Rhamnus jujuba* by botanists. The Jaroo cocoons are produced from a mere variety, not a distinct species, of this insect. The Arrindy silk-worm, however, belongs to an entirely different species, the *Phalæna cynthia* above named. It appears peculiar to two districts in the interior of Bengal, viz. Rungpore and Dinagepore, where it is reared in a domestic state. The food of this caterpillar consists entirely of the leaves of the common *Ricinus*, or *Palma Christi*, which the natives call arrindy, and hence the name by which the insect is itself distinguished.[3] The cocoons are in general about two inches in length and three inches

[1] M. de Villiers has published some new details regarding *S. Australis*, in the *Annales de la Soc. Linn. de Paris*, v. 473. The antennæ in our figure are, we fear, not quite accurately represented, though, from want of a specimen, we cannot correct them. Compare Godart, *Papil. de France*, iii. pl. 22, fig. 29; and Guerin, *Iconog.* (*Insectes*), pl. 85, fig. 4.

[2] This species has been bred at Altona by Mr Zincken von Sommer, from eggs imported from America. We have figured the larva on Plate CCXLIX. fig. 23.

[3] *Edinburgh Cabinet Library*, British India, vol. iii. p. 155.

in circumference, pointed at either end; they are of a white or yellowish colour, and their texture is extremely soft and delicate. The filament indeed is so remarkably fine, that this silk cannot be wound off, but is spun like cotton. The yarn is wove into a kind of coarse white cloth, of a seemingly loose texture; but of such extreme durability that the life of one person is seldom sufficient to wear out a garment of it, so that the same piece frequently descends from parent to child. It must always be washed in cold water.[1]

The principal European species of the genus Saturnia are known under the names of peacock and emperor moths, &c. such as *S. pavonia major* and *minor*. The former is the largest moth in Europe, and has been known to remain in the chrysalis state for three years.

Other Bombycites have the superior wings decumbent, with the exterior margin of the inferior pair projecting almost horizontally beyond them,—*alæ reversæ*. In the genus Lasiocampa (Plate CCXLIX. fig. 26), the palpi project in the form of a rostrum, and the inferior wings are frequently dentated; some of the species bear a resemblance to little bundles of dried leaves; such are *L. quercifolia* and others. In the genus Bombyx properly so called (ibid. fig. 21) the inferior palpi exhibit no remarkable projection. Here is placed the famous *Bombyx mori*, or true silk-worm moth, of a whitish colour, with two or three obscure and transverse streaks, and a lunate spot on the superior wings. The caterpillar feeds on the leaves of the mulberry, and spins an oval cocoon of a close tissue of the finest silk, usually of a yellow colour, but sometimes white. A variety is now preferred abroad, which always yields the latter colour. Although this sumptuous product is now "familiar as household words," its nature and origin were but obscurely, if at all, known in ancient times; and even in the days of Aurelian it was valued at its weight in gold. This was probably owing to the mode in which the material was procured by the merchants of Alexandria, who had no direct intercourse with China, the only country in which the silk-worm was at that time reared. According to Latreille, the city of Turfan, in Little Bucharia, was for a long time the rendezvous of the western caravans, and the chief entrepôt of the Chinese silks. It was the metropolis of the Seres of Upper Asia, or of the Serica of Ptolemy, placed, according to that author, between the Ganges and the Eastern Ocean. Hence the *Serica vestis* of the Romans, and the word *Sericum*, their name for silk. Driven from their country by the Huns, the Seres established themselves in Great Bucharia and in India. It was from one of their colonies, Ser-hend (*Ser-indi*), that certain Greek missionaries, in the reign of Justinian, carried the eggs of the silk-worm to Constantinople. Its cultivation spread, at the period of the first Crusades, from the Morea into Sicily, the kingdom of Naples, and, several centuries afterwards, under the administration of Sully more especially, into France, to which country it is now a source of great wealth. Silks were also anciently obtained by sea or land from the kingdoms of Pegu and Ava, or the Oriental Seres, most frequently mentioned in the writings of the earlier geographers.[2] Though the manufactures of silk were lauded in terms of the highest admiration both by Greek and Roman writers, they were in frequent use for some centuries before any certain knowledge appears to have been obtained, either of the precise countries from which the material was derived, or of the mode by which it was produced. By some it was supposed to be a fine down adhering to the leaves of trees or flowers, by others it was regarded as a delicate kind of wool or cotton;[3] and even those who had some idea of its insect origin were incorrectly informed of the natural mode of its formation. The court of the Greek emperors, which surpassed even those of the Asiatic sovereigns in splendour and magnificence, became profuse in its display of this costly luxury; but as the Persians, from the advantages which their local situation gave them over the merchants from the Arabian Gulf, were enabled to supplant them in all those marts of India to which silk was brought by sea from the East, and as they had it in their power to cut off the caravans which travelled by land from China through their own northern provinces, Constantinople thus became dependent on a rival power for an article which its sumptuous nobles deemed essential to the enjoyment of refined life. Of course the Persians, with the usual rapacity of monopolists, raised the price to an exorbitant height, and many attempts were made by Justinian to free his subjects from such exaction. An accidental circumstance is said to have accomplished what the wisdom of the great legislator was unable to achieve. Two Persian monks, who had been employed as missionaries in one of the Christian churches established in India, had penetrated into the country of the Seres, that is, to China, where they observed the natural operations of the silk-worm, and acquired a knowledge of the arts of man in working up its produce into so many rich and costly fabrics. The love of lucre, mingled perhaps with a feeling of indignation that so valuable a branch of commerce should be enjoyed by unbelieving nations, induced them to repair to Constantinople, where they explained to the emperor the true origin of silk, and the various modes by which it was prepared and manufactured. Encouraged by the most liberal promises, they undertook to transport a sufficient supply of these extraordinary worms to Constantinople, which they effected by conveying the eggs in the interior of a hollow cane. They were hatched, it is said, by the heat of a dunghill, and the larvæ were fed with the leaves of wild mulberry.[4] They grew and prospered, worked their webs, underwent their accustomed metamorphosis, and multiplied their kind according to use and wont; and thus, as already intimated, becoming extensively cultivated throughout all the southern countries of our continent, they effected an important change in the commercial relations which had so long existed between Europe and the East.[5]

Another curious species of the genus Bombyx is the processionnary moth, *B. processionnea*, Fab. The caterpillars of this insect live in society on oak trees, where, when young, they spin in common a silken tent, in which they dwell together in unity. They frequently change their domicil until after the third casting of their skins, on which they remain more stationary, forming a new habitation resembling a kind of sack, divided interiorly into several cells. They usually issue forth in the evening, in a very singular order of procession. A single individual takes the lead, and serves as guide, two others follow, forming the second line, then three abreast, next four, and so on for many ensuing columns, each regularly augmented by the addition of a single larva, and all following the course of their first adventurous leader. After a certain time each spins a cocoon alongside that of its neighbour, mingling the hairs of its body with the silken tissue. These hairs, Latreille remarks, are, in common with those of several other kinds, extremely small and fine; and sometimes working their way into the human skin, occasion

[1] *Account of the Tusseh and Arrindy Silk-Worms of Bengal*, by William Roxburgh, M.D. &c. *Linn. Trans.* vol. vii. p. 33.
[2] *Règne Animal*, t. v. p. 402. [3] Robertson's *Historical Disquisition concerning Ancient India*. [4] Procopius, *De Bello Gothico*.
[5] See Gibbon's *Decline and Fall*, &c. Reign of Justinian; also *Edinburgh Cabinet Library*, British India, vol. iii. p. 152–3.

violent itchings, accompanied by swelling. The inhabitants of Madagascar are known to employ for economical purposes the silk of a caterpillar which likewise dwells in great communities,—a commonwealth of worms. Their nest is sometimes three feet high, and so closely packed with cocoons (500 have been counted in a single mass) that not the smallest hiatus is to be found. The species, however, belongs to the genus *Sericaria* of the ensuing section.

Section 3d, Pseudo-Bombyces.

These consist of Lepidoptera in which the inferior wings (in common with those of all the remaining nocturnal tribes) are provided with a curb, which attaches them to the superior when at rest. They are then entirely covered by the latter, and both are decumbent or horizontal, but with the inner edges overlapped (*en recouvrement*, Lat.). The trunk among the concluding members of the section begins to lengthen, and scarcely differs in the final genera from that of other Lepidoptera, except that it is somewhat shorter. The antennæ are entirely pectinated or serrated, at least in the males. The caterpillars live on the exterior parts of vegetation.

Latreille distinguishes first those species in which the trunk is very short, and apparently unadapted to the purposes of suction.

In some, and these are the greater number, the caterpillars live exposed or uncovered, and do not fabricate portable dwellings. Of these, some are elongated, furnished with ordinary feet, well adapted for walking; the rings of the body not soldered above. In the genera Sericaria of Lat. (Plate CCXLIX. fig. 22), and Notodonta of Ochs. (Plate CCL. figure 1), both sexes have well-developed wings. In the former, which contains the *B. dispar* of Fab. so remarkable for the great size of the female, and the difference of her general aspect when compared with the male, the upper wings exhibit no dentations on their inner border. In the latter, which contains *Ph. zigzag* of Linn. that border is dentated. In the genus Orgyia of Ochs. (ibid. fig. 2), the females are almost apterous (fig. 3), and the caterpillars (fig. 4) are beautifully adorned with aigrettes, or little plumes or tufts of hair. In others of the same tribe the caterpillars creep rather than walk, their feet being extremely short, and even the scaly ones retractile; the body is oval like that of an oniscus, with the skin soldered above from the second ring, so as to form a kind of arch, beneath which the head is withdrawn. These compose the genus Limacodes, Lat. of which the caterpillars seem to represent, in this section of the Nocturna, those of certain diurnal Lepidootera, such as the genus *Polyommatus*.

Other genera of Pseudo-Bombyces are distinguished from the preceding by the possession of a very distinct trunk, which, when unrolled, extends far beyond the head. The disposition of their colours somewhat resembles that of those diurnal species called chess-boards (*damiers*) by the French. Many of them are extremely rich and beautiful in their adornment. In Chelonia of Godart (*Arctia*, Schr.) Plate CCL. figure 5, the wings are decumbent in repose, the antennæ pectinated in the males, the inferior palpi very hairy, and the trunk short. To this genus belongs that common but superb species commonly called the Tiger-moth (*B. caja*, Fab.). It is produced from the blackish-brown creeping caterpillar usually known in Scotland as "the hairy worm." In Callimorpha, Lat. (ibid. fig. 6), the wings are also decumbent, but the antennæ are at most only ciliated in the males; the inferior palpi are merely covered by little scales, and the trunk is long. *C. Jacobæa* is an ornamental British species, known to our elder writers under the names of Pink-underwing, and Cinnabar-moth. The upper wings are brown, with a streak and two spots of carmine. The under pair are carmine, with a blackish border. The caterpillar is hairy and black, and feeds on the flowers of the rag-wort. In Lithosia of Fab. the wings are laid as it were horizontally upon the body.

Section 4th, Aposura, Lat.

The insects of this division are characterized by a peculiarity already alluded to,—the want of feet on the anal segment of the body of the larvæ. They derive their name from that circumstance. The posterior extremity of the body terminates in a point, which in several is forked, or even exhibits two articulated appendages, long and flexile, and forming a kind of tail. The perfect insects differ but little from the preceding in regard to their trunk, palpi, and antennæ. Some, such as Dicranoura of Godart (Plate CCL. figure 7), have the external aspect of Sericaria and Chelonia, with the antennæ of the males terminating in a small simple curved thread. The posterior extremity of the larva is forked (ibid. fig. 8). Others, such as Platypterix, Lat. bear a great resemblance to the Phalænæ properly so called. Their wings are broad, and the superior angle of the posterior extremity of the anterior pair is somewhat prolonged or falcated. The body is slender. That of the caterpillar terminates in a simple truncated point. In that state they bend over the edges of the leaves of plants, and fix them down by silken cords, so as to form a protecting habitation, which at the same time they partly consume as their natural food. The cocoon of the chrysalis is very bare.

Section 5th, Noctuælites, Lat.

The species of this extensive section are similar to the preceding insects in the figure and relative proportion of their wings, and their position in repose; but they present the two following distinguishing characters: A horny, spirally rolled, and generally elongated trunk; inferior palpi, terminated abruptly by a very small article, much more slender than that which precedes it,—the latter being broader and compressed. These genera have the body more covered by scales than by a woolly down. Their antennæ are usually simple. The thorax is frequently crested above, and the abdomen assumes the form of an elongated cone. Their flight is rapid, and some of the species make their appearance during the day. The caterpillars have usually sixteen feet. Some have only twelve or fourteen, but the posterior or anal pair are never wanting; and in those which present but twelve the anterior pair of the membranous ones are as long as the next ensuing. The greater proportion spin a cocoon, in which they undergo their metamorphosis. These Lepidoptera correspond to the division named *Noctuæ* of the genus *Phalæna* of Linn.

All the generic groups recently established, and of which the characters are derived rather from the caterpillar than the perfect insect, are referred by Latreille to the two genera which follow. In the genus Erebus of Lat. (Plate CCL. figures 10 and 14), the wings are always extended and horizontal, and the terminal joint of the palpi is elongated, elevated, cylindrical, or slightly compressed, and naked. With the exception of a single species, *Ophiusa scapulosa* of Ochsenheimer, which occurs in Spain, all these insects are of exotic origin. We have figured a superb example, "the glory of the Noctuidæ," as it is well named by Mr Kirby, on the fourth plate of the first volume of our *Illustrations of Zoology*. It is the *Erebus strix* of Latreille, and is known also under the title of the

great owl moth of Brazil. It measures nearly a foot in breadth from tip to tip of the extended upper wings. In the genus Noctua of Fab. and Lat. (ibid. fig. 9) the terminal joint of the inferior palpi is short, and covered with scales, like that which precedes it.[1] Of those with six feet, which are the greater number, we may mention as a British species *N. sponsa*, Fab. The caterpillar lives upon the oak, is of a greyish colour, and obscurely and irregularly spotted. It is marked with small tubercles, and the eighth ring bears a projection, on which there is a yellow plate. This larva, and some other nearly allied kinds, are called *lichenées* by the French naturalists, on account of their resemblance to, and the difficulty with which they are sometimes distinguished from, various kinds of bark-supported lichens.[2] The anterior four of the membranous feet are shorter than the others, and they walk like the *surveyors*. Many other well-known species are arranged with that just mentioned. The caterpillars of certain others have only twelve feet, and the perfect insects are frequently ornamented with golden or silvery spots upon the upper wings. Such are two well-known British species, *N. gamma* and *chrysitis*. The former of these receives its name from a character resembling the Greek letter γ inscribed in gold upon its upper wings. "This creature," say Messrs Kirby and Spence, speaking of the larva, "affords a pregnant instance of the power of Providence to let loose an animal to the work of destruction and punishment. Though common with us, it is seldom the cause of more than trivial injury; but in the year 1735 it was so incredibly multiplied in France as to infest the whole country. On the great roads, wherever you cast your eyes, you might see vast numbers traversing them in all directions to pass from field to field; but their ravages were particularly felt in the kitchen gardens, where they devoured every thing, whether pulse or pot-herbs, so that nothing was left besides the stalks and veins of the leaves. The credulous multitude thought they were poisonous, report affirming that in some instances the eating of them had been followed by fatal effects. In consequence of this alarming idea, herbs were banished for several weeks from the soups of Paris. Fortunately these destroyers did not meddle with the corn, or famine would have followed in their train. Réaumur has proved that a single pair of these insects might in one season produce 80,000; so that, were the friendly Ichneumons removed, to which the mercy of Heaven has given it in charge to keep their numbers within due limits, we should no longer enjoy the comfort of vegetables with our animal food, and probably soon become the prey of scorbutic diseases."[3] The caterpillars of some other species have the habit of eating the petals of the flowers of the plants on which they dwell. The antennæ of certain kinds are pectinated, such as *N. graminis*, an insect which has sometimes proved extremely destructive to the meadows in Sweden. We may conclude by observing that caterpillars believed to belong to this genus have been seen to exercise a curious, and, as we would suppose it, an unnatural instinct,—they seize upon other larvæ, even of their own species, transfix them by the middle, and sucking out their interior juices, leave them nothing but their own skins. When we mention that Olivier (in *Encyclopédie Méthodique*) describes 459 species of the Fabrician genus Noctua. the reader will readily admit that many of the new generic groups, to which we have been unable to do more than allude, are extremely desirable, were it for nothing else than mere convenience, independent of any higher reasons resulting from the nature of things.

Section 6th, Tortrices, Linn.

These are very nearly allied to the Lepidoptera of the two preceding sections. The upper wings, of which the posterior margin is arcuated at the base and then restricted, and their short and broad contour, forming a truncated oval, bestows a peculiar physiognomy upon the species in question. They are named by the French *Phalènes a larges epaules*, *Phalènes chappes*, &c. They are all provided with a distinct trunk, and the inferior palpi are generally very like those of Noctua, but somewhat projecting. They are of smallish size, agreeably coloured, with the wings decumbent, but flattish, or almost horizontal, and covering the body,—the inner margins of the upper pair even overlapping each other a little in a state of repose. The caterpillars have sixteen feet, a smooth body, or but slightly haired, and dwell in leaves, which they roll up or convert into tunnels by means of silken cordage. They live upon the parenchyma of their own leafy dwellings, which thus serve them both for food and clothing. Others form their dwellings by uniting several leaves together, while a few are found in different kinds of fruits. Several have the posterior part of their body narrower than the others, and these were named *chenilles en forme des poisson* by Réaumur. Their cocoons are boat-shaped, and

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[1] The genus Noctua of Fabricius, as observed by Latreille in his note to the *Règne Animal*, t. v. p. 409, is, in Ochsenheimer's *Schmetterlinge von Europa*, divided into forty-two genera, from *Acronita* to *Euclidia* inclusive. These are constituted in great part by the conversion into genera of the sections previously indicated in the "Systematic Catalogue of the Lepidoptera of Vienna." Their insertion in this article would however be still more incompatible with our own limits than with those of the *Règne Animal*, from which they are expressly excluded. The Noctuæ, according to Latreille, exclusive of *Erebus*, are resolvable into two great parallel series, one of which is related to these latter Lepidoptera, the other to the Notodontæ. The first is composed of those of which the caterpillars march after the manner of the surveyors or Geometræ. Some have sixteen feet, of which the anterior two or four of the intermediate membranous ones are the shortest; others have only twelve feet, such as *Plusia* and *Chrysoptera*, genera distinguished from the preceding by the size of the inferior palpi, which are recurved upon the head. The second series commences with species of which the palpi are proportionally larger, the antennæ pectinated, and the trunk smaller;—such are *Notodonta palpina* (*Odonptera palpina*, Lat.) and the genus *Calyptra* of Ochsenheimer. Then follow the genera *Xylena* and *Cucullia*, those Noctuæ in which the posterior margin of the anterior wings are angular or dentated, those in which the antennæ are pectinated, and those in which they are simple. The latter species are terminated by such as have an even thorax, some of which, belonging to the genus *Erastia*, seem to lead to the Pyralites. All the caterpillars of this second series have sixteen feet, with the intermediate membranous ones of equal size; their mode of progression is rectigrade. The genus *Chrysoptera* (*Plusia concha* of Fischer, in *Entomog. de la Russie*, i. *Lepidop.* iv.), with which Latreille concludes the other series, is related to *Herminia* and *Pyralis*. Thus both series seem to converge towards the latter section. The *Licheniæ*, or *Catacolæ*, of Ochs., are large species, with almost horizontal wings, which, as well as *Ophiusa*, *Brephos*, &c. appear to approximate naturally to Erebus. Latreille is of opinion that if placed in the other series they destroy its harmony.

The *Bombyx cyllopoda* of Dalman (*Analect. Entom.* 102) ought to form a new sub-genus, and of a remarkable nature, in so far as the two posterior legs of the male are shorter than the others, unarmed, and almost useless for the purposes of locomotion. This insect has the antennæ pectinated, a distinct trunk, and the palpi as long again as the head, and ought therefore to be placed near the genus *Calyptra* of Ochs. or *Herminia* of Latreille.

[2] A beautifully providential change has been rendered natural to some of these species in relation to their food. The larva of *N. algæ*, Fab. is always yellow when it feeds on *Lichen juniperinus*, which is itself of that colour; but it becomes grey while pasturing on *Lichen saxatilis*.

[3] Réaumur, *Mém.* ii. 327; *Introduc. to Entom.* i. 189.

are in some kinds formed of pure silk, in others of mixed materials. These insects compose the genus PYRALIS of Fab. (Plate CCL. figure 16). Many of the species are destructive to fruit-trees and vines. *P. pomona* in the caterpillar state lives in the interior of apples, of which it eats the pippins. We may name as a British species *P. prasinaria*, which is the largest known. It measures about two inches in extent. The upper wings are pure green with two oblique streaks in the centre, the thorax is green, the under wings white. This species, with that which we have figured, form the genus *Chloephora* of Stephens.

SECTION 7TH, PHALÆNITES, Lat.

Here are comprised a numerous assemblage of nocturnal Lepidoptera, in which the body is usually slender, with the trunk either apparently wanting, or generally but slightly lengthened, and almost membranous; the inferior palpi are small and nearly cylindrical; the wings ample, extended, and almost horizontal, or flatly decumbent. The antennæ are pectinated in several males. The thorax is always even, or without a crest. The caterpillars have in general only ten legs, though some (*Ph. margaritaria*) have twelve; the anal pair are always present. These insects correspond to the *Geometræ* of Linn., and their peculiar mode of progression, already described in our observations introductory to the lepidopterous order, has obtained for them the name of *surveyors*. Their attitude in repose, also before described, is still more extraordinary.[1] They then resemble little broken twigs of the plant on which they rest; and their colours, and the inequalities of their surface, aid the deception. They thus no doubt frequently escape the observation of their natural foes. Roesel states that his gardener, mistaking one of these ligneous-looking larvæ for a dead twig, the brittleness of which he no doubt expected would admit of his instantly snapping it asunder, started back in the greatest alarm when he found by its consistence and motion that it was a living creature. The chrysalids are almost naked, their cocoons being thin and poorly supplied with silk.

According to Latreille's views, by which we are at present guided, this section, when considered in relation to the perfect insects alone, contains but a single genus, that of PHALÆNA properly so called (Plate CCL. figures 13 and 15) of which the characters consequently agree with those just assigned to the section itself. A very different view, however, has been taken by the greater mass of entomologists, foreign and indigenous; and a roll of names of fearful length and deep construction, has been received by many as constituting a proper portion of our scientific nomenclature. Thus Mr Stephens' family *Geometridæ*, corresponding to the *Phalænites* of Latreille, contains above eighty British genera. The number is precisely eighty-three in Mr Rennie's *Conspectus*. Many naturalists believe that no such divisions as genera exist in nature, and consequently that all our generic distinctions are artificial, and constructed merely for convenience, as a helping instrument for ourselves, and an easier mode of mutual communication between ourselves and others. But all naturalists admit that there is a difference in the value of the characters chosen, and that such as are selected as generic should be pervading and influential over a pretty obvious group, not chosen arbitrarily or at hazard from the examination of the limited productions of any one confined insular region, but on mature deliberation, and after a kindly and extended study of the analogous productions of foreign lands. Characters drawn from form and structure are much less liable to accidental variation, and are likewise of more comprehensive application, than such as are derived from colour;—the former have consequently been used to distinguish the greater groups, including genera, —the latter are chiefly available in the discrimination of species, and their mode, range, and frequency of variation, of themselves afford most interesting subjects of study and reflection, in relation to the varieties of each particular kind. It is doubtful, however, whether the use of the evanescent shades of so superficial a character as colour, is advisable in the distinction of genera. The great test of a good generic character consists in its being in some way connected with or influential over the natural habits of the species which it is assumed to distinguish,—so that it may fairly be presupposed to exist in other species of similar instinctive modes of life. These traits are no doubt difficult to obtain in the insect creation, where the species are so numerous, and the gradations so often insensible from one group to another. But still we know that colour, though occasionally extremely characteristic of natural groups, is a distinction too flighty and fantastical to be generally applied with advantage, otherwise than for artificial combinations. For these and other reasons not necessary to be here adduced, we have hitherto failed to see the propriety of such characters as "first pair of wings somewhat rufous, with darker streaks," "second pair pale, with a red streak," "wings banded with green," "the first pair greenish, spotted with black, the second pair dull," &c. being adopted as *generic* distinctions, —the more especially as they would prove not very efficient even for the purposes of *specific* discrimination.

There is no doubt, however, that the great extent of the genus in question requires that it should be reduced by subdivision within manageable bounds; and if determinate and distinctive characters of sufficient value can be attached to each, a generic name may as well be used as a sectional mark. Hubner has described and figured above 400 European species, and MM. Lepelletier de Saint Fargeau and Serville have formed numerous divisions among the species described by them in the *Encyclopédie Méthodique*. Modern entomologists have adopted a method of distinguishing by the specific name alone, whether the male of a phalæna has the antennæ pectinated or setaceous. The names of such as exhibit the former structure always end in *aria*, those characterized by the latter in *ata*. A very common species is *Ph. Grossulariata*, white, with some yellow streaks, and spotted with black. The caterpillar is also richly coloured. It feeds on the leaves of the currant and gooseberry. The chrysalis is of a shining black, with yellow rings. It is known in England by the name of Magpie. *Ph. ulmata*, or the clouded Magpie, is a scarcer species. In Scotland at least it is rare. Both these belong to the sub-genus *Abraxas* of Leach. A rather large and elegant species, called the swallow-tailed moth, *Ph. sambucaria*, is of a pale sulphur colour, with two transverse streaks upon the upper, and one upon the under wings. It forms the sub-genus *Ourapteryx* of Leach, and resembles in its form the beautiful *Phalæna machaonaria* of Boisduval, which, with *Ph. guttaria*, ibid. we have represented by the figures last referred to. The females of a few present only the rudiments of wings. Such is *Ph. brumata*, which makes its appearance during the winter season, and belongs, for that reason, to the sub-genus *Hybernia* of Latreille.

SECTION 8TH, DELTOIDES, Lat.

This section consists of species very analogous to the true Phalænæ, but the caterpillars have fourteen legs, and

[1] See page 205

live in rolled up leaves. The inferior palpi are elongated and recurved in the perfect insect. The wings form with the body, on the sides of which they spread horizontally, a kind of delta, with a re-entering angle in the middle of the posterior edge, producing a forked aspect. The antennæ are usually pectinated or ciliated. Our present section comprised, in the first edition of the *Règne Animal*, all the *Phal. Pyralides* of Linn. But, as Latreille has more recently observed, a complication of characters resulted from that arrangement, which is obviated by only comprising in this division the genus HERMINIA (Plate CCL. figure 17), which belonged to *Pyralides* of Linnæus, and is composed of the genus *Hyblæa* of Fab. and several species of his genus *Crambus*. These Lepidoptera are generally of a greyish hue, without much brilliancy of colouring. Several species are remarkable for tufts of hairs upon the upper portion of their legs, the use of which in their natural economy has not yet been ascertained. Indeed we know little of the history of the species, although they sometimes attract our notice by the length of their palpi. They have been named *snouts*, *fan-feet*, &c. by the English collectors.

SECTION 9TH, TINEITES, Lat.

Latreille here comprehends the *Phal. Tineæ* of Linn. and the greater part of the *Phal. Pyralides* of the Swedish naturalist. They consist of the smallest species of the lepidopterous order,—among others, of our common house-moths, so well known for their destructive propensities in the larva state, and the ravages they commit among neglected garments. These larvæ are smooth, have always at least sixteen feet, and live concealed either in fixed or moveable habitations, of their own construction. In some the wings form a kind of elongated triangle, almost flattened, and terminated by a re-entering angle;—such are the *Phalænæ Pyralides* of Linn. They have four distinct and usually exposed palpi. In others the superior wings are long and narrow, sometimes moulded on the body, and forming over it a rounded roof,—sometimes inclined almost perpendicularly, applied close to the sides, and frequently elevated posteriorly after the manner of a cock's tail in miniature. In either case the inferior wings are always broad and plaited. The latter kinds also have not unfrequently four exposed palpi.

All nocturnal Lepidoptera, the caterpillars of which lived in sheaths or cases, received from Réaumur the name of *Teignes proprement dites* or of *Teignes fausses*, according as their habitations were detached and portable by the contained creature, or fixed and immoveable.[1] This principle of arrangement, though sufficient for the purposes which the admirable author had in view, is not philosophically founded, and, if strictly applied, would require our including among the Tineites the genus *Pyralis* and others belonging to preceding sections. In the Linnæan system, our present insects composed the seventh division of the great genus Phalæna, and were briefly characterized as follows:—Wings almost cylindrically rolled, front projecting. They constitute a generic group in Geoffroy's work.[2] Following the example of Linnæus, Degeer did not separate these small creatures from the general mass of Phalænæ, but satisfied himself by forming them into different sections of his fourth and following family. Indeed his arrangement of the Phalænæ is extremely artificial.

The Tineites, although they are the pygmies of the lepidopterous order (what a vast disparity in size between a small clothes-moth and the great owl-moth of Brazil!) are much more richly attired than most of their larger brethren. Indeed, when minutely examined, not many created things will be found more worthy of our admiration; and it is not without reason that Scopoli has observed,—" Tinearum copia, parvitas, pulchritudo stupenda, ut in his potissimum natura thesauros suos effudisse videatur, tantaque in minimis hisce majestas, ut admirari potius eam liceat, quam aptis verbis indicare."[3] The wings frequently combine, with extreme beauty of colouring, the most brilliant little stripes and masses of shining silver and burnished gold, which under the microscope exhibit a most radiant richness. This lustrous aspect of many species is however but a poor recompense for the injury which we receive from many more while in the larva state. These clothe themselves at our expense in the warmest woollen garments, which they traverse in all directions, leaving behind a gnawed and worn-out path, so thin and bare as to yield to the slightest pressure. They also destroy furs, hair, feathers, and many other articles of domestic economy, and are the exterminating pests of zoological museums. To them we no doubt owe the destruction of the famous Dodo, once preserved in the Ashmolean Museum of Oxford, and never since seen by human eyes. By means of their maxillæ these little larvæ shear down the surface of various substances, and uniting the particles by means of their glutinous silk, they thus form protecting habitations, which partake of the nature of the woollen or other stuffs on which the foresight of their parents has placed them. When they themselves increase in bulk, so as to find their abodes as inconvenient as a strait waistcoat, they split them down the middle, and interpose a piece, proportioned no doubt to their expected as well as actual increase. They add to the length also by fresh materials to the anterior end. These observations are easily made by removing the young larva in its first restricted case, from a piece of white to a piece of scarlet or other coloured flannel. When about to undergo their transformations they close up the apertures with silk. Another larva of this section (*Teigne des blés*), which Olivier makes an *Alucita* and Latreille an *Œcophora*, is still more destructive on account of its ravages among corn, and its prodigious powers of multiplication. Our grain is also liable to great damage from the larvæ of other Tineæ, such as the *fausse chenille des blés*, described by Réaumur, which, by means of its silken web, connects together several grains in the form of a tunnel, from which it issues forth to feed on the neighbouring heaps. It is a somewhat analogous species which in bee-hives pierces the waxen cells on which it feeds; and by thus causing the honey to flow out, occasions great loss to the apiarian. Our readers must have frequently observed the leaves of many plants and trees pervaded by numerous tortuous windings, of a paler colour than the rest. These are the sub-cutaneous galleries of certain very small larvæ of garden-moths, many of them extremely beautiful, and so minute as to dwell at ease between the upper and under surface of the leaf. Others dwell and feed upon the surface, but screened from immediate observation by a covered way of silk, which they spin along their devious courses. Referring the curious reader to the works of Réaumur, Roesel, and Degeer, for a more ample history of these truly singular and interesting tribes, we shall here briefly notice a few of the principal genera.

In the following groups the four palpi are always dis-

[1] The *Teignes aquatiques* of Réaumur are the larvæ of *Phryganeæ*; and those to which he applies the ancient name of *Ligniperdæ* are the larvæ of the genus now called *Psyche*, belonging to the section *Pseudo-Bombyçites*.

[2] *Histoire des Insectes des Environs de Paris.*

[3] *Entomologia Carniolica*, p. 243.

tinct,[1] exposed, or simply concealed (the upper ones), in part by the scales of the epistoma, and are advanced, of medium size, and analogous to those of the *P. pyralides* of Linn. Their wings are decumbent, generally flattened, or but slightly raised, and form a kind of delta or elongated triangle. In the ensuing genera the trunk is apparent, and serves for the performance of the usual functions. The larvæ live on various plants. In Botys, Lat. (Plate CCL. fig. 11), the larvæ roll up leaves, and do not differ externally from the others except in the respiratory organs. In Hydrocampe, Lat. (ibid. fig. 12), the species are analogous to the preceding, but the caterpillars are aquatic, and are usually furnished with filiform appendages, the interior of which contain tracheæ. They fabricate tunnels or covered ways with the leaves of various aquatic plants. Such are *H. potamogata, paludata, lemnata*, &c. In the genus Aglossa of Lat. (ibid. fig. 19) the trunk is wanting, or nearly so. The four palpi are exposed, and the wings form a flattened triangle,—the upper having no emargination at their extremity. *A. pinguinalis*, Réaum. iii. xx. 5–11, occurs on walls in houses. The caterpillar is smooth or short-haired. of a brownish black, and shining. It feeds on various fatty substances, and also attacks leather,—on which account it is called *fausse-teigne des cuirs* by Réaumur. It is destructive to the binding of books, and is therefore an inconvenient companion in a library. Its case consists of a long tunnel, applied close to the substance on which it lives, and covered by particles of excrementitious matter. According to Linnæus, it occurs, though rarely, in the human stomach, where it occasions effects much more dangerous and alarming than those caused by ordinary intestinal worms. " Un médecin éclairé, " says Latreille, " et dont je ne puis révoquer en doute la véracité, m'a envoyé des chenilles de cette espèce, qu'une jeune famille avait vomies." Another species, *P. farinalis*, feeds on flour. In the genus Galleria of Fab. the scales of the clypeus or epistoma form a projection which covers the palpi. The upper wings, proportionally narrower than those of Aglossa, and emarginate on the posterior border, are, in common with the inferior, very decumbent, and raised posteriorly like a cock's tail, as in many species of the ensuing genera. *G. cereana*, Fab. is the species the larva of which is designated *fausse-teigne de la cire* by Réaumur. It is extremely destructive in bee-hives, in which it pierces the honey cells, and constructs as it advances a silken tunnel covered with excrementitious particles composed of the wax which it has devoured. The cocoons of the chrysalids are sometimes found assembled in heaps.

In other groups of Tineites the superior palpi are not always very distinct. The upper wings are long, narrow, sometimes moulded or rolled upon the body, sometimes applied perpendicularly to the sides. In this state the insect has always an elongated and narrow form, approaching that of a little cylinder or cone, when the wings are closed.

In the next-named four genera the inferior palpi, always large, are borne, as it were, in advance, the last joint at most being raised. The palpi are apparent. Crambus, Fab. (Plate CCL. figure 20), has a distinct trunk. The inferior palpi project straight forwards like a beak. These Lepidoptera occur in dry pastures and on various plants. Alucita, Lat. (ibid. fig. 22), has also a distinct trunk, but the inferior palpi are raised. The antennæ are simple. In Euplocampus, Lat. (ibid. fig. 18), the trunk is short and inconspicuous, and the last article of the inferior palpi is likewise raised, the scales of the preceding one forming a faisceau. The antennæ of the males are furnished with a double row of little barbs. The genus Phycis of Fab. is closely allied to Euplocampus, but the antennæ at most are merely ciliated.

In the following genera the inferior palpi are entirely raised, and even recurved over the head in several. Sometimes the inferior palpi are very apparent, and of medium size. The antennæ and the eyes are distinct. In the two following genera the inferior palpi scarcely surpass the front. In Tinea (ibid. fig. 21) the trunk is very short, and formed of little membranous disjointed threads. The head is erected. The species of this genus, which has been greatly restricted since the time of Fabricius, are particularly destructive among our clothes and other household concerns. We shall here notice a few of the principal kinds. *Tinea tapezana*, Fab. and Lat., has the upper wings black on the basal portion, their posterior part being white. This is the species represented by our figure.[2] Its caterpillar feeds on woollens, on which it forms an arched gallery, lengthening as it advances. *T. sarcitella* is of a silvery-grey colour, with a white spot on each side of the thorax. Though very abundant and extremely destructive in most parts of Europe, its synonymy and consequent history are somewhat confused. The figures given by Réaumur,[3] and cited by many authors, appear (at least if we judge from the eleventh) to belong to another genus. The inferior palpi are large, recurved and pointed, a character which rather allies it to the genus *Volucra* of Lat.[4] and to the *T. vestianella* of Scopoli and Linn. It is even suspected that these two insects are the same. According to the last-named authority, the *T. sarcitella* is of a silvery grey, as above described. In *T. vestianella* the upper part of the head, of the thorax, and even the base of the superior wings, are white. The inferior palpi, recurved in the manner of horns, are of the same colour, ringed with black. The wings lie horizontally on the body, are whitish, and shining, and the upper surface of the superior pair presents some blackish spots of different sizes. The inferior are of a uniform colour, bordered posteriorly, as is also the internal margin of the upper pair, with long fringes. This species is extremely common, and it has been presumed that Linnæus having given an inadequate description from a defective specimen, its identity became difficult to recognise, and that thus Scopoli bestowed a new name, that of *vestianella*, upon an old species.[5] However this may be, the *T. sarcitella* is extremely pernicious among all woollen substances. It forms and inhabits a silky case, usually spindle-shaped, which it covers with detached hairs or particles of wool. *T. pellionella*, Fab. has the upper wings of a silvery grey, with one or two black points on each. Its caterpillar forms a felted case or tunnel, and lives on furs, which it destroys with ease and satisfaction to itself, by gnawing off the hairs at the base. The wings of *T. granella* are elevated behind, and marbled with grey, brown. and black. Its larva is very injurious to grain. *T. flavifrontella*, Fab. has a *toupee* of a more lively colour than the other parts, approaching to reddish. Its larva forms a silken case, and is extremely hurtful in museums, among birds, insects, &c.

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[1] The genera *Iponomeuta* (with one or two exceptions), *Œcophora*, and *Adela*, are, according to Latreille, the only Tineites of which the superior or maxillary palpi are not distinctly perceptible; but as they may be concealed by the inferior or labial palpi, it is difficult, in relation to this point, to establish a fixed and rigorous line of demarcation. For this reason the French entomologist has not arranged the Tineites according to the number of the palpi. M. Savigny, in his *Memoires sur les Animaux sans Vertèbres*, has given figures, in which these parts are represented in their various proportions. (*Règne Animal*, v. p. 417.)

[2] It is identical with *T. tapetzella* of Linn. and the lamented Mr Haworth.

[3] *Mémoires*, iii. vi.

[4] *Règne Animal*, t. v. p. 412, note.

[5] See *Dict. Classique d'Hist. Nat.* xvi. p. 87.

We may conclude by observing, that the most efficient means of preventing or removing moths are care and cleanliness. Let articles of such a nature as may be liable to their injurious inroads be frequently examined, handled, and exposed to light and air. These tiny creatures are lovers of darkness, and of undisturbed repose. The instinct of the mother (and that providential perception is never more unerring than when manifested in relation to the welfare of a future offspring) teaches her to distinguish whatever is neglected or cast aside,—and in like manner she becomes sensible that whatever is used or often handled would form an unsafe nidus for her tender young. In depositing her eggs she therefore selects the one and rejects the other; and hence a careful housewife, who feels a lively interest in her own concerns, and frequently examines and refolds or arranges her household gear, may live for half a century and never see a moth. At the same time, if articles are rolled up in a perfectly close and well-ordered tissue, they are safe from these destructive creatures, which are certainly never *bred* from the things they consume, however old or ill-conditioned. But if a single unsuspected crevice should chance to admit one solitary female moth, " the spinster's occupation's gone," and a colony of worms is suddenly produced from innumerable eggs, which would strike horror into the heart of a Malthusian. Where things must be left unexposed to changes of light and air, and yet cannot be hermetically closed, the use of camphor, spirit of turpentine absorbed upon pieces of sponge or cotton, and other preventives, are tried with more or less success. Exposure to a brisk fire is the most effectual means of expelling the larvæ from stuffed birds, quadrupeds, &c.

In the genus Ilithyia, Lat. (Plate CCL. figure 23), the inferior palpi resemble those of the preceding genus, but the trunk is distinct, and of the ordinary size, and the last article of the inferior palpi is obviously shorter than the preceding. In Iponomeuta, Lat. (ibid. fig. 24), the trunk is also distinct, and of tolerable size, but the terminal article of the inferior palpi is at least as long as the preceding one. These insects, according to Latreille, are related to Lithosia. *Y. evonymella* (Tinea of Fab.) has the upper wings of a shining white spotted with black, the inferior pair lead colour. *Y. padella*, Lat. has the upper wings of a greyish-lead colour, and very numerously spotted with black, the under pair lead coloured, with thick fringes. The caterpillars of both these kinds live in large congregations, beneath a dusky web, which they stretch out upon our fruit-trees, of which they devour the leaves. When they have eaten all within their reach at one place, they make a start to another, enclose themselves under a new and more extended canopy, and recommence their ravages, which are found to be extremely injurious to the health of the tree, and its productive powers. The branches seem as if covered with patches of dusty and discoloured crape. In the genus Œcophora, Lat. the inferior palpi are recurved above the head, in the manner of horns, proceeding to a point, and reaching as far backwards as the back of the thorax.

Lastly, in a few species, such as those of the genus Adela, Lat. (Plate CCL. figure 25), the inferior palpi are very small and clothed, the antennæ are almost always extremely long, and the eyes approximate. These beautiful little creatures occur in woods, and are said to appear with the leafing of the oak. They are frequently brilliantly ornamented with metallic scales. The species which we have figured is *A. Degeerella*, remarkable for its antennæ being many times the length of its body. These delicately articulated organs are whitish, the posterior portion black. The upper wings are of a gilded yellow on a dark ground, forming longitudinal streaks, with a broad transverse golden-yellow band bordered with violet.[1]

Section 10th, Pterophorites, Lat.

This, our concluding section of the nocturnal Lepidoptera, exhibits many relations to the preceding, in respect to the narrow and elongated form of the body and upper wings; but it differs from it, as well as from all the other sections, in this, that a pair, if not all, of the wings, are as it were split or cloven throughout their whole length, so as to present a branched or digitated appearance, bearded on the edges. The parts look like feathers, so that the wings of these fantastically formed creatures somewhat resemble those of birds. They formed the division of *Phalænæ alucitæ* of Linnæus, and were named Phalènes-tipules by Degeer. Geoffroy, Fabricius, and Latreille include them under the genus Pterophorus. Their larvæ have sixteen feet, live on leaves and flowers, and construct no cases. The chrysalids of the greater number are naked, coloured, and suspended by a thread. In others they are enclosed in a translucent cocoon. The genus has been lately subdivided. In some the inferior palpi are recurved from their origin, entirely garnished with small scales, and do not exceed the length of the head; these constitute the genus Pterophorus properly so called, of Latreille (Plate CCL. figure 26). Their chrysalids are exposed, beset with hairs or small tubercles, and are sometimes suspended by a thread, sometimes fixed by means of hooks at the posterior extremity to a little bed of silk, imposed upon a leaf or other vegetable body. *P. pentadactylus*, Fab. is an example of this division. The wings are of an almost snowy whiteness, the upper pair being divided into two, the lower into three parts. In others the inferior palpi are projected, longer than the head, with the second article thickly covered with scales, and the terminal one almost naked, and turned up. The chrysalis is enclosed in a cocoon of silk. To these Latreille has applied the generic name of Orneodes (ibid. fig. 27). The *O. hexadactylus* measures about six lines in length. It is of an ash-coloured grey, with a tinge of brown. The wings, especially the upper ones, are traversed by obscure or blackish bands, with some spots of a paler grey; and each wing is divided to its base into three principal parts, of which the first is subdivided into two radii, and the second into three: the third is simple. The caterpillar of this species has sixteen feet, and lives on the honeysuckle, *Lonicera xylosteum*. The perfect insect is often found on walls and windows, and in the interior of houses. It is widely spread over Europe.

We here take leave of the lepidopterous order, and shall only further remark, that we seek in vain to express by words the splendid colours, the elegant and varied forms, and the exquisite pencilling, by which they are adorned. Even the most richly illumined pages of natural history

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[1] In the arrangement of these insects, given by Latreille in the second edition of the *Règne Animal*, and by which we have been guided above, he has apparently, with the view of approximating to the nomenclature of Réaumur, combined the *Pyralides* and *Tineites* in one section. He has however elsewhere indicated the propriety of their being disjoined, and in this event the following genera will compose the Tineites: I. Inferior or labial palpi advanced; the terminal articulation at most elevated; superior palpi apparent: Genera Galleria, Crambus, Alucita, Euplocampus, and Phycis. II. Inferior palpi altogether elevated, or even recurved, in several, over the head. A. Inferior palpi of medium size, and very obvious; eyes distant: Genera Tinea, Ilithyia, Iponomeuta, Œcophora. B. Inferior palpi very small and hairy; eyes approximate: Gen. Adela.

convey but a meagre image of their gorgeous attire. That must be sought for—where alone it can be found,—in those far more brilliant and inimitable pages of the *book of nature*, in which the most successful effort of art is transcended by a feeble insect's wing. The imagination of poet and of painter cannot boast,

Amid their gay creation, hues like these.

ORDER VII.—STREPSIPTERA, KIRBY.[1]

The singular insects which constitute our present order are parasitical species, which dwell, while in the larva state, between the plates of the abdomen in different kinds of wasps and bees. Their characters were first given by Mr Kirby (*Linn. Trans.* vol. xi. p. 109), who bestowed upon them the name above adopted, and which was subsequently altered, without sufficient reason, by Latreille. The definition given by the former author, in his later work, is as follows: Metamorphosis sub-incomplete? Pseudelytra twisted, attached to the anterior leg. Wings not covered by the elytra, longitudinally folded, forming nearly the quadrant of a circle: neuration simple. Anus styliferous.[2] On each side of the anterior extremity of the thorax, near the neck and the exterior base of the first pair of legs, are inserted two small crustaceous bodies, like rudimentary elytra, stretching backwards, curved, dilated, and terminating near the origin of the true wings. These are the *pseudelytra* just named, called *prebalanciers* by Latreille. The great French entomologist is of opinion, that, as elytra properly so called always cover the totality of the base of the membranaceous wings, and derive their origin from the second segment of the thorax, the parts in question are not genuine wing-cases, but rather analogous to the tippets (*pterygoda*), observable at the base of the upper wings in the lepidopterous order. The actual wings of Strepsiptera are large, membranaceous, divided by longitudinal nervures, proceeding like rays from the shoulder or point of union with the body. They fold lengthways like a fan.[3] The mouth is composed of four pieces, of which the shorter two appear to be biarticulate palpi, the others, inserted near their base, have the form of little linear laminæ, pointed, and crossing at the extremity, like the mandibles of various insects, but resembling rather the lancets of the sucker of the dipterous tribes, than true mandibles.[4] According to Savigny's views, the mouth consists of a labrum, two mandibles, a pair of maxillæ, each bearing a very small uniarticulate palpus, and a labium without palpi. The head presents two large eyes, hemispherical, granose, and slightly pediculated; two antennæ, approximate at the base, placed upon an elevation in common, almost filiform, short, and composed of three articulations, of which the first two are very short, and the third, greatly elongated, is divided from its origin into two long compressed lanceolate branches, applied against each other. The stemmatic eyes are wanting. The thorax, in its peculiar form and divisions, resembles that of several Cicadariæ, Psyllæ, and Chrysides. The abdomen is nearly cylindrical, composed of eight or nine segments, and is terminated by pieces which seem to bear an analogy with those which we find at the posterior extremity of the Hemiptera above named. The six legs are almost membranous, compressed, nearly equal, and terminate in filiform tarsi, composed of four membranous articulations, which appear vesicular at their extremity, and of which the terminal one, somewhat larger than the others, is unfurnished with hooks. The four anterior legs are approximate, the posterior pair being thrown pretty far back by themselves. The space comprised between the latter pair is ample, and divided into two by a longitudinal groove or furrow. The posterior extremity of the metathorax is prolonged over the abdomen in the manner of a large scutellum, and its sides, which serve as points of insertion to the posterior legs, are much dilated backwards, and form a kind of inflated buckler, which defends the exterior and lateral base of the abdomen.

These singular insects were first observed by Rossi, who concluded, because they were parasitical, that they must belong to the hymenopterous order, to which they certainly bear a greater affinity than to any of the dipterous tribes, among which they were arranged by M. Lamarck. Latreille inclines to consider them as related (although at the same time differing in various ways) to certain hymenopterous species, such as those of the genus EULOPHUS. In the larva state they live between the abdominal plates of hymenopterous insects belonging to the genera *Andrena* and *Polistes*. It has been supposed that the elytra-like portions, already described, serve to disengage the perfect insects with greater facility from the living chambers in which they are incased. They are said to frisk about with a simultaneous motion of these organs and the true wings. Latreille calls them the *Œstri* of insects. We know that a species of Conops likewise undergoes its transformations in the interior of a Bombus, or wild bee.

This order contains only two genera,—XENOS of Rossi, and STYLOPS of Kirby. Their exact nature is still of difficult determination, as will be perceived from the following quotation:—" The true place in nature," says Mr Macleay, " of the singular genera *Xenos* and *Stylops*, is indeed very difficult to determine; and what remarks, therefore, I am now about to offer on them ought to be received by the reader with great caution, as well because it has hitherto been out of my power to become acquainted with them, except through the medium of the works of Kirby, Latreille, Savigny, and Lamarck, as because the total variance in the statements of these authors respecting them demonstrates that their true nature is as yet by no means ascertained.

" Professor Peck and Savigny, however, have both most satisfactorily shown that the *Strepsiptera* are provided with true mandibles and palpigerous maxillæ; and therefore have completely set aside the opinion of MM. Lamarck and Latreille as to their affinity with the *Diptera*. Proceeding, then, on the fact that they belong to the *Mandibulata*, which, by the by, appears at last to be admitted by Latreille, we necessarily make inquiry as to the particular part of this class in which they ought to be placed. Now, the only chasms of importance which we have noticed in the column, are one between the *Trichoptera* of Kirby and the *Tenthredines*, and the other between the *Hymenoptera* and the *Coleoptera*. The deficiency of ocelli, the structure of the whole insect, but particularly that of the wings, prove that the *Strepsiptera* cannot occupy any vacancy near the *Trichoptera*. It therefore only remains for us to place them between the *Hymenoptera* and *Coleoptera*. But this appears to be nearly the situation originally given to the *Strepsiptera* by Mr Kirby; for, in his very remarkable paper on those insects, in the eleventh volume of the *Linnæan Transactions*, he says, ' With respect to the place of *Strepsiptera* in the system, it seems to me that this order should follow *Coleoptera*; for its metamorphosis being different from that of *Orthoptera* and *Hemiptera*, and near-

[1] RHIPIPTERA, Lat.

[2] *Introduc. to Entomology*, iv. 370.

[3] Hence the name of *Rhipiptera*, bestowed upon them by Latreille, from ῥιπις, *a fan*, and πτερα, *wings*.

[4] *Règne Animal*, v. 425.

Strepsiptera.

er to that of the *Coleoptera*, this seems its most natural station, considered as an elytrophorous order, especially since, if it be inserted between *Orthoptera* and *Hemiptera*, with both of which it has some affinity, it would interrupt the series of semicomplete metamorphosis, by which, besides other characters, these two orders are so closely united.' He had previously noticed a circumstance which at once distinguishes them from all *Coleoptera* and *Orthoptera*, and gives them an affinity with the *Hymenoptera*, namely, a narrow collar instead of an ample thoracic shield. And it is worthy of remark that Rossi, in the work which informed naturalists of their existence, placed them among the *Hymenoptera*, induced to this, as Mr Kirby supposes, by the economy of their larvæ. Such, then, is in all probability their true place in nature, though certainly my opinion on the subject, for the reasons already stated, ought to be received, as it is advanced, with great caution. The *Xenos*, beyond a doubt, is, with the *Stylops*, the most puzzling insect to place naturally that we know; it is truly '*animal animum excrucians*;' and no better proof of this can be given than that when Lamarck and Latreille make the *Strepsiptera* a division of *Diptera*, they seem absolutely to have pitched on the most artificial situation for them which they could have chosen. Latreille has remarked that the body of the *Strepsiptera* bears a striking relation to that of some *Homoptera*; and to judge from the descriptions given by Mr Kirby of these insects, their wings are folded like those of *Orthoptera*, while the form of their head resembles that of some *Neuroptera*. To the *Diptera* they have no visible affinity, and scarcely any analogy, except such as we might expect from their proximity to the *Hymenoptera*. How far I am right in adopting Mr Kirby's opinion as to their real affinities, remains yet to be seen; but it is no weak argument in support of its accuracy, that they possess the very precise kind of metamorphosis which insects in the hiatus between the *Coleoptera* and *Hymenoptera* ought to have from analogy.

" The *Strepsiptera* ought probably to be considered as an osculant order; and they undoubtedly form a group which is apparently of much greater importance, and is marked with much stronger characters, than the *Dictuoptera*. These can scarcely be said to afford a type of any very peculiar construction, and may therefore, perhaps, with more propriety, be viewed as an annectent tribe falling into the extensive order of *Orthoptera*."[1]

In the genus Stylops, the last portion of the antennæ is composed of three small articulations. The abdomen is fleshy and retractile. *S. Melittæ*, Kirby, measures about a line and a half in length, and is quite black, with brown legs. The wings are longer than the body. The larva is soft, almost cylindrical, and whitish. Its head is advanced, horny, heart-shaped, a little flattened, of a reddish colour, black posteriorly, and somewhat concave beneath. It lives in the bodies of *Andrenæ*, and when about to be transformed to a chrysalis or pupa (Plate CCXLIV. fig. 29), it fixes itself more outwardly, between the abdominal plates. It occurs in Britain and the continent of Europe. Additional species have been lately discovered by Mr Dale and others, and will be found described in the works of Messrs Curtis and Stephens.

In the genus Xenos established by Rossi,[2] and so excellently illustrated by Mr Kirby,[3] the terminal branches of the antennæ are not articulated. The abdomen is corneous with the exception of the termination, which is fleshy and retractile. We are acquainted as yet with the detailed history of only two species. The first is the *Xenos vesparum*, now called *X. Rossii*, in compliment to its discoverer. It inhabits, and is frequently found in, a European hymenopterous insect or wasp called *Vespa (Polistes) gallica*. The individuals of the latter kind infested by the Xenos are readily known by the unnatural swelling of the fourth segment of the abdomen, from which the insect in the perfect state is usually found to emerge. Sometimes one, not seldom two, and occasionally three, are seen to escape from the same wasp. They generally come forth in the winged state in August and September; and if during that period the pupa be extracted with a needle from the abdomen of the wasp, the covering broken open, and the white tunic carefully stripped away, living specimens may be obtained. The mode in which these parasites are originally placed on their living prey is not yet known. It is possible that the egg may be laid in the larva of the wasp before its cell is closed. Rossi at least seems to be of this opinion, although Mr Kirby, reasoning from analogy, thinks it unlikely that it should be deposited on the wasp in its first state, while the larva feeds on it in its last. It has been a subject of wonder to naturalists that these Vespæ, after supporting one or more parasites, should survive; yet we know that they are often met with in a most active and vigorous condition, with only the exuviæ of the Xenos remaining in them. It has been stated as an explanation of this, that the time during which the insect remains in the larva state is very short; and as it does not attack the thorax of the wasp, the muscular energy and general vital powers of the latter thus escape destruction. The other species to which we alluded is the *X. Peckii* (Plate CCXLIV. figs. 30 and 31), so named after an American naturalist, Professor Peck, by whom it was made known to Mr Kirby. This species measures one and a half lines in length. It is of a blackish-brown colour, the legs livid, the tarsi brown. The branches of the antennæ are subdiaphanous, and spotted with white. The larva inhabits a North American wasp called *Polistes fuscata*, of which it so distorts the abdomen that, according to Professor Peck, there is no difficulty in distinguishing the infested individuals even on the wing. " Taking them," he observes, " with the gauze forceps, bringing them into a close room, and permitting them to fly to the windows, I caught them again with a wine glass and a card, fed them with sugar, and thus preserved them till their parasites were disclosed. I had not the pleasure to see them emerge, but found them soon after." " In the feeding state the head of the larva is near the abdomen of the wasp, as I found by dissection. When the feeding state is passed, it is easy to conceive that it turns, and with its flattened head separates the membrane which connects the abdominal scuta, and protrudes itself a little way, accurately closing the aperture, which is but just large enough to admit it. All this time the wasp is active, and associates with its companions. When just protruded, the head of the larva is of a pale-brownish colour; by degrees it assumes a rounder form, and becomes almost black. The chrysalis state ensues; but I suspect that only the part exposed to the air, and that immediately under the pressure of the abdominal rings, becomes hard."[4]

We shall now pass from this limited order to one of much greater extent and more ancient constitution.

Order VIII.—DIPTERA.[5]

The numerous order of dipterous or two-winged insects, of which the common house-fly affords a familiar

[1] *Horæ. Ent.* p. 370.

[2] *Faun. Etrusc. Mant. Append.* p. 114.

[3] In his essay *On a new Order of Insects*, *Linn. Trans.* vol. xi. p. 86.

[4] *Linn. Trans.* vol. xi. p. 90.

[5] Antliata, Fabricius.

example, is characterized by possessing a pair of veined and membranous wings, with two moveable bodies called balancers (*halteres*) placed a little behind them. The mouth consists of from two to six setaceous pieces of a scaly texture, and its parts are either enclosed in the upper groove of a probosciform sheath, terminated by two lips, or covered by one or two inarticulate laminæ, which form the sheath.[1]

Dipterous species, like all other hexapod insects, are composed of three principal portions. The head is more or less globular or hemispherical, often concave posteriorly, so as to fit better on the front of the thorax, and is susceptible of turning on itself, as on a pivot, from right to left, and *vice versa*. The greater part of its surface, especially in the males, is generally occupied by the eyes, which are often very beautiful, being composed of a vast number of facettes, lighted up as it were with a metallic splendour. When ocelli or stemmatic eyes exist in this order, they are always three in number, and placed upon the vertex. When the mouth (which is not adapted for chewing or bruising solid substances, but only for extracting and transmitting fluids) consists of six pieces, it then exhibits all the parts analogous to those of masticating insects. Of these parts a single superior portion represents the labrum, and a single inferior portion the ligula properly so called, of the coleopterous and orthopterous orders. The four other parts are disposed in pairs; the upper pair corresponding to the mandibles, the lower to the terminal portion of the maxillæ of the masticating orders. The basal portion of the maxillæ also exists, but it is always very short, and confounded with the fleshy mass, which serves as the base of the trunk, and precedes its first geniculation. Thus in the Muscides, for example, the sucker consists of only two setæ, and is yet accompanied by a pair of palpi, which, according to analogy, can only be those of the maxillæ. Seeing that the piece representing the labrum is inserted, with the other portions of the sucker, near the geniculation of the trunk, and at some distance from the anterior margin of the head,—and that, in other insects, the labrum is always fixed to that margin,—it becomes necessary that a portion of the base of the clypeus, or epistoma as it is now called, should be incorporated with the support of the sucker. We have just stated that the inferior portions of the maxillæ are likewise united with the supporting part, which, when not in action, is withdrawn into the oral cavity. It is not thus with the Lepidoptera and Hemiptera,—the corresponding portion of the maxillæ in these orders being fixed and immoveable, and the labrum always preserving its relative position. In some Diptera the sucker is composed of only four pieces, and then the *mandibular* setæ are wanting or imperceptible. Indeed in a great number we perceive only two pieces, and in that case it is the single pieces only (*impaires*), that is, the labrum and ligula, which are cognisable. The reduction in the number of these parts is, according to Latreille, a proof of the inferiority of the dipterous order, when compared with the generality of insects. The sucker in our present order performs the office of a lancet, by piercing the envelope of vegetable fluids, or the vessels which contain the juices of animals. These liquids, by pressure of the parts, are then forced to ascend the internal canal to the pharynx, situate at the inner base of the sucker. The lancets are often grooved or furrowed, by which they become more compactly enclosed, and act in common. The sheath or external part merely serves to maintain the lancet *in situ*, and seems to represent the lower lip of the triturating orders. It is frequently bent upon itself, at an angle more or less acute, when the insect is using the sucker. This becomes obvious when we examine a gnat or mosquito in the act of pumping our blood.

The antennæ of the Diptera are usually inserted on the front, and are approximate at their base. In the family called Nemocera by Latreille (*Culex* and *Tipula*, Linn.), these organs resemble those of the nocturnal Lepidoptera in form and position, but in his other families they seldom consist of more than two or three articulations, the last of which is fusiform, or shaped like a lenticular or prismatic pallet, provided either with a little styliform appendage, or a thickish hair or seta, itself sometimes simple, sometimes pilose.

The thorax appears as if composed of only a single segment, the first, or prothorax, being very short, or sometimes evanescent, and the metathorax being also very short, and occupying only the posterior extremity, situate beneath the scutellum. The mesothorax, or intermediate portion, thus becomes the principal apparent segment. It bears on each side a pair of stigmata, of which, however, the anterior is frequently alone distinguishable.

The neuration of the veins of the wings is simple These parts are usually horizontal. Meigen's figures of the wings (of which we have availed ourselves in the plates connected with this article) are extremely exact. He confines himself, however, chiefly to the antennæ in the formation of his generic characters, without having recourse to Jurine's method of employing the neuration of the organs of flight,—a method, indeed, the application of which in the dipterous tribes is attended with greater difficulties than among the hymenopterous order. It has, however, been used in relation to the Diptera by Fallen, and other systematic authors.

Above the true wings, and a little behind them, are two small moveable bodies, almost membranous or slightly corneous, usually pale in colour, nearly linear in the greater part of their extent, but with a knob or button-like mass at the extremity, capable of dilatation. These are the balancers or *halteres*, of the nature and supposed uses of which we have already spoken at sufficient length in our general introductory observations.[2]

Above the balancers we find two membranous or papyraceous pieces, usually white or yellowish, ciliated, united together by one of their sides, and having the form of two valves of a shell applied upon each other. These are the winglets, or *ailerons* of the French writers.[3] Their size seems to be in an inverse proportion to the length of the balancers, which to a certain extent they cover and protect. One of them is attached to each of the corresponding wings, and participates in its movements,—but during flight the valves are held in separation, or nearly on the same plane.

The abdomen of dipterous insects is frequently attached to the thorax by a portion only of its transverse diameter. It is composed of from five to nine apparent segments, and in the females usually terminates in a point; in those, however, in which the segments are fewer, the terminal ones form a kind of ovipositor, presenting a succession of small tubes which slip into each other somewhat after the fashion of the different portions of a telescope. It results from this conformation that several of the hinder stigmata are by no means distinctly perceptible.

The legs are usually long and slender, and are terminated by five-articulate tarsi, with two hooks at the extre-

[1] See Pl. CCXXXIII. fig. 7, *a*, *b*, *c*, *d*,—and the detailed description given at page 35, note 4.
[2] See page 41, note 2.
[3] We name them *wing-scales* in the ensuing portion of this treatise, from the German word *schuppschen*, used by Meigen.

mity, besides, in many instances, two or three small cushion-like expansions, either membranous or vesicular. It is by means of these last-mentioned parts, according to certain authors, that flies are enabled to creep up the smoothest perpendicular surfaces, or to walk on ceilings with their backs downwards.[1]

Dr Derham had long ago observed that "diverse flies and other insects, besides their sharp-hook'd nails, have also skinny palms to their feet, to enable them to stick on glass and other smooth bodies, by means of the pressure of the atmosphere."[2] This opinion, very generally adopted by entomologists, derived additional weight from Sir Everard Home's papers on the subject, illustrated by drawings from the always admirable pen of Mr Bauer.[3] The structure of the parts, however, has been variously described by different authors, and by some in such a manner as (supposing their descriptions accurate) to render the organs unfit for the uses supposed, or at least for the particular mode of action assigned by Derham and Home, and coincided in by Messrs Kirby and Spence.[4] Thus Dr Hooke described the house-fly as having the soles of its feet beset underneath with small bristles or tenters, like the wire teeth of a card for working wool, and which he conceived to give them a strong hold upon any object having irregular or yielding surfaces. In regard to glass, which is neither yielding nor irregular, he imagined that it bore upon it a kind of smoky substance, penetrable by the points of the bristles.[5] The want of accordance in these accounts lately induced Mr Blackwall to inspect the parts minutely under a good compound microscope, when he immediately became convinced that the function assigned by the writers we have first named was incompatible with the actual organization. "Minute hairs," he observes, "very closely set, and directed downwards, so completely cover the inferior surface of the expanded membranes, improperly denominated suckers, with which the terminal joint of the tarsi of flies is provided, that it cannot be brought into contact with the objects on which those insects move, by any muscular force they are capable of exerting. The production of a vacuum between each membrane and the plane of position is therefore clearly impracticable, unless the numerous hairs on the under side of these organs individually perform the office of suckers; and there does not appear to be any thing in their mechanism which in the slightest degree countenances such a hypothesis."[6] Mr Blackwall then procured living specimens of the house-fly, *Musca domestica*, and of the large flesh-fly, *Musca vomitoria*, and enclosed them in clear jars and phials of transparent glass, the interior surface of which they traversed in every direction with the greatest facility, even walking upon it with their backs downward, while they remained in full vigour; but when enfeebled either by exposure to cold or by the fatigue of over exertion, the identical individuals ascended the sides of the same jars and phials with difficulty (falling from them frequently), and were altogether incapable of adhering in an inverted position. No sooner, however, were they recruited by repose or an increase of temperature, than they again repeated those extraordinary feats, to which custom makes us callous, with all their original dexterity. He likewise found, that flies which are unable to maintain an inverted position on highly polished bodies, will frequently adhere firmly, with their backs downward, to glass defective in polish or slightly soiled. This and other facts plainly indicated that flies are not supported on the vertical sides of smooth bodies either by the pressure of the atmosphere or by the aid of a glutinous secretion (as conjectured by some authors), but by means strictly mechanical, as suggested by Dr Hooke. It has been found, in fact, that the house-fly, while it retains its vital powers unimpaired, can not only traverse the upright sides, but even the interior of the dome of an exhausted receiver; and that the cause of its relaxing its hold, and ultimately falling from the station it occupies, is a diminution of muscular force attributable to impeded respiration.[7]

In regard to the anatomical structure of the dipterous order, the following is the substance of the observations on the subject given by M. Marcel de Serres, in his admirable memoir *Sur le Vaisseau dorsal des Insectes*. The dorsal vessel (now regarded as the heart) is itself narrow, and its pulsations frequent. The respiratory system consists of vesicular tracheæ, communicating with each other by tubular tracheæ, and unfurnished with those cartilaginous hoops which we find in the Orthoptera. The nervous system is generally composed of a small cerebriform ganglion with approximated lobes, from which proceed large optic nerves; two medullary cords of the ordinary kind (already described in our preceding general introduction) form from space to space about nine ganglia, of which three belong to the thorax and six to the abdomen. The intestinal tube presents, 1*st*, an œsophagus extending to the base of the abdomen; 2*d*, a rather elongated stomach, somewhat narrow, and furnished at its origin with a considerable number of hepatic vessels; 3*d*, a cylindrical duodenum, also accompanied by hepatic vessels, but of narrower dimensions; 4*th*, a short and muscular rectum.

All the Diptera dissected by M. Dufour were provided with salivary glands, a character which that accurate observer regards as being common to all insects furnished with a sucker. The structure, however, of those parts varies according to the genus.[8] They no doubt serve to increase the fluidity of the nutritive juices absorbed by the sucker. We may add, that both Dufour and Dutrochet have observed that the stomach of many Diptera is accompanied by a kind of paunch, in which a portion of the aliments is deposited.

Many tribes of this extensive order, if not decidedly noxious, at least occasion us great annoyance, not only by sucking our own blood, but by laying their eggs on the bodies of our living domestic animals, and on whatever uncooked fleshy viands they can attain to, especially during sultry weather, when the process of corruption is the most speedy, and the insects themselves are in their prime of strength and vigour. On the other hand, they may be regarded as serviceable, on account of the rapid consumption, by their most gluttonous larvæ, of all animal and several vegetable substances in a state of putridity. Their term of life in the perfect state is but of short duration. A few months or even weeks elapse, and their merry course is run. Such as contrive to fight their way to the conclusion of the ambiguous autumn, perish on the first approach of frost. A few half-benumbed house-flies indeed are generally seen in our apartments till Christmas time; and the delusive gleam of a sunny winter day not

[1] *Phil. Trans.* 1816. An analogous structure, according to Sir Everard Home, enables the walrus to ascend the inclined plane of a slippery iceberg.

[2] *Physico-Theology*, p. 363, note 6.

[3] *Phil. Trans.* for 1816.

[4] *Introduc. to Ent.* vol. ii. letter xxiii.

[5] *Micrographia*, p. 170.

[6] *On the Pulvilli of Insects, Linn. Trans.* vol. xvi. part iii. p. 488.

[7] *Ibid.* p. 490.

[8] *Recherches Anatomiques sur l'Hippobosque des Chevaux, Annales des Sciences Nat.* vi. 301.

seldom re-animates their feeble forms so far as to produce a dubious buzz about our windows; but such as show themselves in open places are speedily snapped up by redbreasts and other feathered epicures, greedy of insect food at that unaccustomed season; and it is probable that few survive till spring. As their eggs, however, are generally deposited in a putrescent nidus, adapted to the propensities of the incipient young; and as that nidus is not of a nature to remain for a length of time unconsumed, it may be fairly inferred that our summer swarms are produced originally from a few individuals, which in some snug corner have survived the most inclement season of the year, and are not the result (as happens in the case of many lepidopterous kinds) of eggs which have been laid during the preceding autumn. It is possible that such as assume the pupa state towards the close of summer under ground, may rest secure in that condition, till called into their winged existence by the returning warmth of the enlivening spring.

All these insects undergo a complete metamorphosis, and are remarkable in this, that the larvæ do not change their skins except at the period of their passing into the nympha state. Some form a kind of cocoon; but others remain uncovered, and can scarcely be even said to change their skin, which seems to harden over them, so as to form an egg-like case for the enclosed pupa. Dipterous larvæ are apodal or without feet, although some which belong to the family Nemocera of Lat. are provided with appendages which serve the same purpose. The head is sometimes projected and constant in its form, sometimes variable in figure, capable of being withdrawn into the body, and undistinguishable from the other segments except by its anterior position, and the existence of the parts of the mouth. This soft and changeable form of the head is, we conceive, peculiar to the larvæ of the present order. It is generally furnished with one or two retractile hooks, and some nipple-like projections. The principal orifices of respiration are almost always placed at the posterior extremity; and in many species there is also a pair of stigmatic openings on the segment next the head. Such as dwell in water, or inhabit corrupt and fluid matters, have their bodies terminated posteriorly by a tail-like prolongation, susceptible of being lengthened or withdrawn according to circumstances, and ending in a radiated expansion, which communicates with internal tracheæ. There are few pieces of natural mechanism so ingenious and admirable as the respiratory systems of the rat-tailed worm, and of the larvæ of gnats and other aquatic Diptera.

We have already alluded to the peculiar transformation of these insects. The skin of the larva seems to harden over and enclose the nymph. The body of the contained insect first detaches itself to a certain extent from the outer skin, leaving on its inner surface the exuviæ of its external organs. In its early state it presents only a soft or gelatinous mass, without distinct characters; but after a time the parts of the perfect insect begin to be developed, and it finally escapes from its prison by butting with its head against the upper part of the case, which ere long opens as it were upon a hinge, like the lid of a cylindrical snuff-box.

The general characteristics of this order are obvious to the eye of an ordinary observer, and are designated in the works even of the most ancient naturalists. Yet Fabricius, by placing with the Diptera certain Arachnides, and the parasitical species of the genus Pediculus, falsified the essential nature of the order. It cannot be denied, however, that here, as in all other great natural groups, there are anomalous or aberrant genera, which depart in a great measure from the ordinary conditions of their kind. Thus, among the pupiparous tribes, the wings, the balancers, and the usual sheath of the sucker, show a tendency to disappear in many species; and in *Nycteribia* and *Melophagus* the organs of flight are entirely wanting.[1]

DIVISION I.—PROBOSCIDEÆ.

The apex of the proboscis with a fleshy labium, and the haustellum covered by a horny labrum; before these are placed two jointed palpi.

A. The antennæ consisting of many joints.

FAMILY I.—TIPULARIÆ.

Antennæ extended forwards, consisting of six or more distinct joints. Palpi standing out, jointed. Halteres naked. Abdomen with seven or eight segments.

a. Culiciformes.

Eyes lunate: ocelli wanting: antennæ of the males plumose, of the females pubescent: mouth not elongate: palpi five-jointed: thorax without a cross suture: abdomen consisting of eight segments.

*

Proboscis extending forwards, longer than the antennæ; palpi straight; wings with the nervures and margin covered with scales.

Genus Culex, Linn. Antennæ porrect, or extending forwards, filiform, fourteen-jointed; plumose in the male, pilose in the female; palpi porrect, five-jointed, longer than the proboscis in the male, very short in the female; proboscis porrect, the length of the thorax: wings scaly, incumbent. Meig. *Zw.* pl. i. fig. 1–10.

The species of this and of some nearly allied genera are extremely troublesome towards evening, especially in the neighbourhood of moist or marshy places. They are greedy of blood, and under the well-known names of Gnats, Mosquitoes, &c. they persecute man and beast, not only sucking our "life-stream," but instilling a poison which, though feeble from its minute quantity, yet often produces pain and inflammation. Although abundant in Italy and all the warmer countries of the earth, they are nowhere more troublesome than amid the barren wastes of Lapland. They feed also on vegetable juices. The female deposits her eggs in the water to the amount of several hundreds, and the larvæ are consequently very frequent in all stagnant pools in spring and summer, where they may be seen when undisturbed, suspended from the surface, with their heads downwards. At this time they breathe by the caudal extremity; but in the nympha state, during which they are still aquatic, the respiratory organs are placed upon the thorax. On assuming the perfect state, the light exuviæ of the nymph serve as a support, by means of which the imago sustains itself for a time on the surface of the waters. The whole of these transformations are passed through in the course of three or four weeks. It is said that the females alone annoy us as blood-suckers. Their

[1] The principal works on this order are, Fallen's *Diptera Suecica*, 4to, 1814–17; Meigen's *Systematische beschreibung der bekannten Europaischen Zweiflugeligen Insecten*, 8vo, 1818–1830 (by this work we are guided in the ensuing portion of our article); Wiedeman's *Diptera Exotica*, 8vo, 1821; and Macquart's *Insectes Diptères du Nord de la France*, 8vo, 1826–9, published in the *Mém. de la Soc. Royale*, &c. de Lille.

shrill nocturnal pipe, the prelude to a closer contact, is particularly distressing in many continental countries, especially to an inexperienced traveller, unprovided with a *cousinière* or mosquito curtain. The Laplanders defend themselves by means of smoke and grease.

C. *pipiens.* Palpi and antennæ dark brown: thorax rufous, nearly rust colour, with two brown longitudinal lines: abdomen ringed with whitish grey and dark brown: halteres whitish: wings unspotted: legs pale brownish, the base of the thighs yellowish; the apex of the tibiæ with a small spot of changeable white. Length three lines. Fab. Linn. Réaumur. Wood's *Illus. of Linn. Genera of Insects*, pl. xcvii. Common in almost all countries.

Genus Anopheles, Meigen. Antennæ porrect, filiform, fourteen-jointed; plumose in the male, pilose in the female: palpi porrect, five-jointed, the length of the proboscis: proboscis porrect, the length of the thorax: wings scaly, incumbent. Meig. *Zw.* i. 10, pl. i. f. 11–17; Curtis, *Brit. Ent.* v. pl. ccx.

A. *bifurcatus.* Plume of the antennæ brownish grey in the males: the two terminal joints of the palpi forming a flat club; circle round the eyes white: thorax ash grey, with a dark-brown line on the sides, and three others down the middle: abdomen grey, ringed with brown: legs brown, the thighs yellowish: halteres dirty white; wings unspotted. The colour of the female is yellowish brown. Three and a half lines. Curtis, *l. c.* *Culex bifurcatus*, Linn. According to Linnæus, the larva, like those of the preceding genus, reside in the water, and the perfect insect does not bite. Only one other species is described by Meigen, which is distinguished by having five dusky spots on each wing. Two others are described in the third volume of the *Zoological Journal.*

Genus Ædes, Hoffmgg. Antennæ porrect, filiform, fourteen-jointed; plumose in the male, pilose in the female: proboscis porrect, as long as the thorax: palpi very short: wings scaly, incumbent. Meig. *Zw.* i. 13.

Æ. *cinereus.* Greyish brown: thorax reddish, pubescent: wings unspotted: thighs rather paler than the other parts of the leg: palpi very short, in other respects not differing much from Culex. Two to two and a half lines. Apparently a rare and imperfectly known insect.

* *

Proboscis shorter than the antennæ; palpi incurved.

Genus Corethra, Meig. Named from the Greek word κόρηθρον, *a brush*, with reference to the appearance of the antennæ. Antennæ porrect, filiform, fourteen-jointed; verticillately plumose in the male, pilose in the female: palpi standing out, incurved, four-jointed, the first joint shortest: wings incumbent, the nervures villose, and the hinder margin ciliated with scales. Meig. *Zw.* i. 14, pl. i. f. 18–23.

C. *pallida.* Whitish: plume of the antennæ brown; eyes black: thorax with three pale-brown abbreviated lines: thighs and tibiæ white, spotted with black; the joints of the tarsi somewhat brownish: wings hyaline, with an obsolete brownish shade over the middle. Male two and a half, female two lines. Meig. *Zw.* vol. i. pl. i. fig. 23, *female.* Found on the continent of Europe. *C. plumicornis* and *culiciformis* inhabit Britain, and have been described, with their usual felicity, by Réaumur and Degeer. Their larvæ differ from those of Culex in their usually horizontal posture. That of *C. plumicornis* is remarkable for its translucent texture, which renders it almost invisible. It was hence called *Tipula cristallina* by Degeer.

Genus Chironomus, Meig. (Plate CCLI. figure 1). Antennæ porrect, filiform, in the male plumose, thirteen-jointed; the terminal joint very long (ibid. fig. 1, *a*); in the female six-jointed, pilose; palpi standing out, incurved, four-jointed; wings lanceolate, deflexed. Meig. *Zw.* i. 18, pl. ii. f. 1–7.

C. *elegans.* Head light yellow; plume of the male antennæ brown; female antennæ pale yellow, the terminal joint brown; thorax hood-shaped in front, elongate, sulphur-yellow, with fulvous vittæ, and having three black spots on each side in the form of a triangle, towards the base of the wings; abdomen sulphur-yellow; legs fulvous, thick, with black joints and a ring of the same colour in the centre of the middle and hinder tibiæ; anterior tarsi not elongate; wings white, with three black points not far from the hinder margin, one towards the middle, and two others near each other, towards the apex. Three to three and a half lines. Meig. *Zw.* vol. i. pl. ii. f. 7, *female.* This rare species, represented by the figures last referred to, has been taken lately at Raehills in Dumfriesshire. We believe it to have been previously unknown in Britain. The genus is very extensive, comprehending little short of a hundred species, the greater portion of which inhabit Britain. The little pink-coloured tortuous worm, frequent in water-barrels, is the larva of *Chironomus plumosus.*

Genus Tanypus, Meig.; named from τανυω, *to stretch out*, and πους, *the foot.* Antennæ porrect, filiform, fourteen-jointed; in the male plumose, with the twelve lowest joints globose, the thirteenth very long, the terminal short and acute; in the female pilose, all the joints globose, the terminal thickest; palpi standing out, incurved, four-jointed, the basal joint shortest; ocelli wanting; wings lanceolate, deflexed, pilose. Meig. *Zw.* i. 55, pl. ii. f. 8–12.

T. *varius.* Male. Antennæ and palpi brown; head and thorax grey, the lines on the latter dark brown, with a grey play of colour in the middle; abdomen yellowish, banded with brown, and having a blackish line on the back; legs brownish yellow, the knee and apex of the tibiæ brown; halteres white; wings with an oblique grey cloud before the apex, having two dark-brown spots in it near the anterior border, and three smaller dark spots at the hinder margin; there is a grey spot at the apex of the wing, and near the middle a rather broad band, in the anterior part of which are placed three blackish spots, two behind each other, and the third, which is smaller, beneath, forming a triangle. The female is of a yellower hue than the male, and the marks on the back, as well as the bands on the abdomen, are paler; the wings are marked in a similar manner. Male three to three and a half, female two to two and a half lines. Meig. *Zw.* i. pl. ii. fig. 12, *male.* Frequents banks and hedges, but is not common. It occurs near London, and in some other parts of England.

The *Tipula maculata*, of which the history is given by Degeer, belongs to this genus. Twelve species are described by Benoit Frederick Fries, in his *Monograph* of the Swedish Tanypi. His work is enriched by some new historical details. Above twenty species occur in Britain.

Genus Ceratopogon, Meig. The generic name is derived from κερας, *a horn*, and πωγον, *a beard.* Antennæ porrect, filiform, thirteen-jointed, the eight lowest joints globose (bearded externally in the male), the following cylindrical, elongate; palpi porrect, incurved, four-jointed, the joints unequal; ocelli wanting; wings parallel, incumbent. Meig. *Zw.* i. 68, pl. ii. f. 13–18.

The larvæ of these insects differ from those of most of their congeners in not being aquatic. They inhabit vegetable galls. The species are numerous, and of small dimensions. Meigen describes forty-five different kinds, of which about one half have been detected in Britain.

C. *bipunctatus.* Black; the antennæ, including the brush of the males, dark brown; thorax clothed with fine yellow pubescence; halteres white; wings thickly covered

with grey pubescence, and having a whitish spot in the middle of the anterior margin; legs pitch-brown; tibiæ with long hairs externally; pubescence of the tarsi white. One line. *Tipula bipunctata*, Linn.; *Forcipomyia pictipennis*, Megerle; *Labidomyia bipunctata*, Stephens. Inhabits England and various parts of the continent.

Genus Macropeza, Meig. So named from μακρος, *long*, and πεζα, *the foot*, the hinder legs being remarkable for their length. Antennæ porrect, filiform, fourteen-jointed; the joints cylindric, the five last longest: wings lanceolate, elongate; hinder legs very long. Meig. *Zw.* i. 87, pl. iii. f. 1, 2.

M. *albitarsis*. Head black, with a broad forehead without ocelli; thorax cinereous, with three narrow black lines, the central one widest; sides of the thorax and shoulders black; scutellum cinereous; abdomen black; halteres white; wings hyaline, with pale-brown nervures; legs black, the tarsi whitish; the hinder legs uncommonly long, particularly the tarsi, which are as long as the thighs and tibiæ united. Length one and a third. Length of the wing two and two thirds, of the hinder legs four lines. Pl. iii. f. 1, *female*. The female only of this singular insect appears to be known: it has not occurred in Britain.

b. Gallicolæ.

Eyes lunate: antennæ with hairs disposed in whirls; palpi incurved; wings pubescent, obtuse, with two or three longitudinal nervures; tibiæ without spurs at the end.

Genus Lasioptera, Meig. The name is from λασιος, *hirsute*, and πτερα, *wings*. Antennæ porrect, filiform, consisting of many joints, which are globose and hairy; ocelli wanting: wings incumbent, villose, with two nervures. Meig. *Zw.* i. 88, pl. iii. f. 3–5.

L. *picta*. Female. Antennæ black, shorter than the thorax, cylindrical, twenty-four jointed; the joints nearly globose and pubescent: thorax black; abdomen black, margined with white, and having two triangular white spots on each segment: thighs yellow; tibiæ and tarsal joints white, with the apex black: halteres white: wings ash-grey, having a narrow black edge anteriorly, in which there is a white spot. One line. Meig. *Zw.* i. pl. iii. fig. 3, *female*. *Diomyza Juniperi*, Megerle.

Occurs on the continent of Europe, but is rare.

Genus Cecidomyia, Latreille. Antennæ projecting, moniliform, many jointed, the joints remote from each other: ocelli wanting; first joint of the tarsi very short: wings incumbent, villose, with three nervures. Meig. *Zw.* i. 93, pl. iii. fig. 8–12.

C. *palustris*. Thorax pale, with three broad black vittæ: abdomen flesh-red; the halteres white. *Tipula palustris*, Fab. Linn. Not unfrequent in Britain and elsewhere. We have nearly thirty indigenous species, among which *C. tritici*, commonly called the *wheat-fly*, is an object of great interest to the agriculturist.[1]

Genus Campylomyza, Wied. Antennæ projecting, cylindrical, fourteen-jointed, the two radical joints thickened: ocelli three: wings pilose, with three nervures. Meig. *Zw.* i. pl. iii. fig. 6–7.

C. *bicolor*. Female. Antennæ dark brown: head and thorax black, somewhat shining: abdomen dark brown, with pale incisures: halteres white: legs testaceous: wings hyaline. Half a line in length.

Found in April and May in hedges, not common.

c. Noctuæformes.

Eyes lunate: ocelli wanting: antennæ moniliform, with a seta at the base: wings broad, villose, with numerous longitudinal nervures, but without cross nerves: tibiæ without spurs.

Genus Psychoda, Lat. (Plate CCLI. figures 2 and 2 *a*). Antennæ projecting, moniliform, pilose, many jointed, the two radical joints thick, the remainder globose, and remote from each other: palpi standing out, four jointed, the joints equal: ocelli wanting: wings broad, lanceolate, villose, without transverse nerves. Meig. *Zw.* i. pl. iii. fig. 13–18.

P. *palustris*. Head, thorax, and abdomen covered with white wool-like hairs: wings black at the apex, the centre with a dark-brown band, which forms an acute angle in the middle, the base shaded with brown; fringe dark brown, white at the apex of the wing: halteres dark brown: legs white; apex of the tibiæ and the two last tarsal joints black. Two lines. Meig. *Zw.* i. pl. iii. fig. 18. Found in Britain occasionally, along with above a dozen other species. We know little of the habits or metamorphoses of these insects. They occur in moist and impure, as well as in marshy places.

d. Rostratæ.

Eyes somewhat rounded, separated on the forehead; ocelli wanting: head elongated into a rostrum anteriorly: palpi incurved: thorax with an arched suture across the middle: abdomen eight-ringed: tibiæ more or less spurred.

Genus Erioptera, Meig. From ειρος, *wool*, and πτερα, *wings*. Antennæ projecting, setiform, sixteen-jointed, the first joint cylindrical, second cup-shaped, the following ovate: ocelli wanting: palpi standing out, incurved, cylindrical, four-jointed, the joints equal: intermediate legs shorter than the others: wings incumbent, parallel, the nervures villose.

E. *maculata*. Dirty yellow, as well as the antennæ and legs: thighs brown at the apex, and having a brown ring in the middle: palpi brown; the abdomen with a brown line along the back: wings with pale nerves and ferruginous ocellated spots, which are partly single and partly form a macular band. Two and a half lines. Inhabits Britain and the continent of Europe. We have about thirty ascertained indigenous species.[2]

Genus Limnobia, Meig. From λιμνη, *a marsh*, and βιοω, *I live*. Antennæ projecting, setiform, the joints from fifteen to seventeen, the radical joint cylindrical, second cup-shaped, the remainder oblong or globose: palpi standing out, incurved, cylindrical, four-jointed, the joints equal: ocelli wanting: wings generally incumbent and parallel, the nervures naked. Meig. *Zw.* i. pl. iv. v. vi.

L. *rivosa*. Antennæ as long as the head, setiform, reddish brown; palpi of a similar colour: head grey; the forehead with a small protuberance behind the antennæ: thorax light grey, with reddish-brown vittæ; scutellum yellowish; metathorax bright grey: abdomen light grey inclining to red, with a reddish-brown line on the back, which is waved on the sides, and has a grey play of colour in the middle: legs rather thick, testaceous, the thighs darker: halteres yellow: wings clear hyaline, having a testaceous streak along the anterior margin; not far from the base another streak leaves the marginal one and runs along the third longitudinal nerve, and from this a third runs along the cross nerves, forming an obtuse angle; the anterior streak has a semicircular projection near the middle, and just behind the base there is a transparent marginal streak with a black spot. From twelve to thirteen lines. *Tipula rivosa*, Linn.; *Tipula triangularis*, Degeer; *Pedicia rivosa*, Lat.

Rare on the continent. In Scotland we lately observ-

[1] See *Linn. Trans.* iv. 230, and v. 106.

[2] The genus is named *Eriopteryx* by Mr Stephens—a commendable change, in as much as it avoids a termination characteristic of the *ordinal* rather than the *generic* groups of Entomology.

ed it in considerable numbers in several of the northern counties, frequenting marshy glades by the sides of rivers. It likewise occurs in the vicinity of Edinburgh. The genus Limnobia is rather extensive, containing upwards of sixty European species, the greater proportion of which are indigenous to Britain. Degeer has published some curious details regarding the manners and metamorphoses of *L. replicata*.[1]

Genus Rhipidia, Meig. Antennæ projecting, fourteen-jointed, the radical joint cylindrical, second and third cup-shaped, the following globose, remote, pectinated on two sides in the male: palpi standing out, incurved, cylindrical, four-jointed, the joints nearly equal: ocelli wanting: wings incumbent, parallel. Meig. *Zw.* i. pl. v. fig. 9–11.

R. *maculata.* Forehead light grey; palpi and antennæ brown, the latter twice the length of the head: thorax bright grey, with a brown vitta, which has an indistinct brown line close to it on each side behind: abdomen dark brown: halteres pale yellow: legs long, thin, brownish yellow; the apex of the thighs, the tibiæ, and the tarsi, brown: wings hyaline, the surface sprinkled with pale brown spots, some of which at the anterior border are larger and darker, and the cross nerve is margined with brown. Three lines. Meig. *Zw.* i. pl. v. fig. 11, *male.* Inhabits England, Germany, &c.

Genus Ctenophora, Meig. Antennæ projecting, thirteen-jointed, the radical joint cylindrical, second globose, third oblong, the following pectinated in the male, in the female simple, globose or ovate: palpi standing out, incurved, cylindrical, four-jointed, the terminal joint elongate: ocelli wanting: wings spreading, shining.

C. *bimaculata.* Head black: palpi rufous beneath, brown above: antennæ dark brown, the joints globular in the female: thorax and abdomen black; the latter in the female marbled on the sides and belly with rufous, which sometimes runs into orange-yellow, spots; the abdomen of both sexes has a greyish transverse spot at the base: halteres and legs rufous; the apex of the thighs, the tibiæ, and the tarsi dark brown: wings hyaline, the anterior margin yellow, having a dark-brown band, extending half way across, and the apex of the same colour. Male six, female from seven to eight lines. *Tipula bimaculata,* Linn. Found in Britain, with six other species belonging to the same genus.

Genus Tipula, Linn. (Plate CCLI. figures 3 and 3 *a.*) Antennæ projecting, thirteen-jointed, the radical joint cylindrical, second cup-shaped, the following cylindrical and pilose: palpi standing out, incurved, cylindrical, four-jointed,[2] the terminal joint elongate: ocelli wanting: wings lanceolate, spreading.

T. *oleracea.* Palpi and antennæ dark brown, the two lowest joints of the latter yellowish grey; forehead bright grey, with a reddish-brown line; the snout yellowish brown: thorax bright grey, having a testaceous dorsal line bounded with dusky; metathorax whitish grey: abdomen testaceous, with a dusky line on the back, which is scarcely perceptible; thighs and tibiæ testaceous, the apex and the tarsi dark brown: halteres brown: wings pale brown, the anterior margin bordered with testaceous, but not to the apex; behind this border there is a whitish streak. Eleven lines. Linn. Fab. Degeer, Lat. This species is common in meadows. It is known in England by the title of *Harry Long-legs,* and is called *Jenny Nettles* in Scotland. The genus Tipula, considered in relation to Europe, contains forty-four species, several of which are large and conspicuous insects, and many of them are very plentiful. *T. crocata,* of a deep velvet black with yellow bands, is a very ornamental species. We have taken it near Edinburgh.

Genus Nephrotoma, Meig. Antennæ projecting, in the male nineteen-jointed, with the first and third joints cylindrical, second cup-shaped, the following excised; in the female fifteen-jointed, the first and third joints cylindrical, second cup-shaped, the following somewhat cylindrical, thickened at the base: palpi standing out, incurved, four jointed, the terminal joints elongate: ocelli wanting: wings lanceolate, spreading. Meig. i. pl. v. f. 19–22.

N. *dorsalis.* Antennæ with the first and second joints ferruginous, the rest black: ground-colour reddish yellow; the forehead with a black vitta: thorax with three shining black lines; the sides of the breast unspotted: scutellum with a black spot; metathorax marked with a black line, and the hinder margin of the same colour: abdomen with a black dorsal line, and a longitudinal line of the same colour on the sides and belly: thighs and tibiæ ferruginous, the apex brown: tarsi dark brown: halteres yellow: wings nearly hyaline, slightly clouded with brownish yellow, the stigma dark brown: the apex of the wing is likewise brownish. Male five and a half, female seven lines. Found in hedges during summer, but is not common. It has occurred in the vicinity of London.

Genus Ptychoptera, Meig. Antennæ projecting, sixteen-jointed, the radical joint short and cylindrical, second cup-shaped, third long and cylindrical, the following oblong: palpi standing out, incurved, elongate, four-jointed, the first joint shortest, second and third long, and of equal length, the fourth very long, setaceous: ocelli wanting: wings spreading, plicate at the hinder margin.

P. *contaminata.* The prevailing colour is shining black: palpi ferruginous: antennæ dark brown: the sides of the breast silky grey: scutellum testaceous: abdomen of the male with two ferruginous bands, that of the female with two ferruginous spots on both sides: legs rufous: the apex of the thighs, the tibiæ, and the tarsi, dark brown: halteres rufous, the knob brownish at the tip: wings nearly hyaline; near the middle of the anterior border is a dark-brown abbreviated band; between this and the apex there is a brown marginal spot, and two or three others at the anterior margin. Male three and a half, female five lines. *Tipula contaminata,* Linn. Fab. Lat. Not rare during summer in Britain and other parts of Europe.

Genus Nematocera, Meig. Antennæ projecting, filiform, six-jointed, the radical joints cylindric, second cup-shaped, the following cylindrical, equal: ocelli wanting: palpi standing out, incurved, four-jointed, the joints equal.

N. *bicolor.* Head ash-grey; forehead wide, brighter at the eyes: thorax bright grey, with three dark lines on the back, that next the side short: abdomen flat, dark brown: legs of the same colour, the base of the thighs, and likewise the halteres, yellow: wings rather dull, without a stigma. Five lines. Meig. *Zw.* i. pl. vi. fig. 1.

Seemingly rare: we are unacquainted with its native country. The specimens from which Meigen took his description were preserved in the collection of M. Baumhauer.

Genus Anisomera, Hoff. Antennæ projecting, setaceous, six-jointed, the radical joint cylindrical, second cup-shaped, third very long: ocelli wanting.

A. *obscura.* Antennæ brown: the prevailing colour of the body brownish grey; thorax with three wide dark

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[1] *Memoires,* t. vi. plate 20.

[2] Latreille says, " de cinq articles,"—but he counts the radical tubercle, which does not seem to have been regarded in Meigen's enumeration.

lines: along the abdomen of the males, which is nearly hoary, runs a narrow vitta, and on the under side of the first segment there is a broad yellow spot, and a smaller one on the second; wings brownish yellow, especially at the cross nerves; legs yellowish brown; the apex of the thighs dark; the anterior thighs thicker and shorter than the others. Four lines. Meig. *Zw.* i. pl. vii. fig. 5, *male.* Found in Germany, Portugal, and England. In the latter country another species has occurred, which has been named *A. lucidipennis.*

Genus Trichocera, Meig.; from τριξ, *hair*, and κερας, *a horn.* Antennæ projecting, setiform, the two lower joints thickened, the remainder oblong and pubescent; palpi standing out, incurved, cylindrical, five-jointed, the joints nearly equal: wings incumbent.

T. *hiemalis.* Palpi, antennæ, and legs, dark brown: head grey: thorax greyish, with four distinct brown vittæ, the hinder part unspotted: abdomen wholly dark brown passing into grey; the caudal process in the female shining black: halteres pale yellow, with a brown knob: wings pale grey or somewhat brownish, unspotted. Two and a half lines. *Limonia hiemalis*, Lat. Abundant in October and November, and usually found throughout the winter. Another British species, *T. regelationis*, is also often seen on walls and houses, even during that inclement season

e. Fungicolæ.

Eyes round or oblong, separated on the forehead: ocelli unequal, sometimes wanting. Palpi incurved, four-jointed: thorax without a cross suture: abdomen seven-ringed: coxæ long: tibiæ spurred.

*

Antennæ setiform, with indistinct joints, the two lower ones thickened.

Genus Dixa, Meig. Antennæ projecting, setiform, the two lowest joints thickened, the rest pubescent: palpi standing out, incurved, cylindrical, four-jointed, the first joint very short: ocelli wanting: wings incumbent, parallel.

D. *aprilina.* Palpi and antennæ dark brown: head brownish yellow, with a large blackish heart-shaped spot on the forehead: thorax light yellow, passing into brown, and marked with three dark lines: abdomen dark brown: halteres yellowish, with a brown knob: legs brownish yellow; apex of the thighs, of the tibiæ, and the tarsi, dark brown: wings hyaline, somewhat whitish, with brown nerves. Two lines. Meig. *Zw.* i. pl. vii. fig. 12, *male.* Found on the continent and in Britain. Meigen describes four species, two of which occur in this country, which also produces a third, named *D. variegata* by Mr Stephens.

Genus Bolitophila, Hoff. Antennæ long, setiform, projecting forwards, the two radical joints thick: ocelli three, placed on the forehead in a transverse line: wings incumbent, parallel, obtuse.

B. *fusca.* Head yellowish, with dark-brown antennæ: thorax yellowish, with three brownish lines on the back: abdomen, halteres, and legs, dark brown; basal half of the thighs yellow, which gradually passes into brown: wings somewhat greyish, with a brown spot at the stigma. Two to two and a half lines. English examples of this species are preserved in the British Museum. According to Mr Curtis, two other kinds inhabit Britain, viz. *B. maculipennis* and *B. cinerea;* the former of these does not appear to be known to continental naturalists. M. Guerin has published a complete and detailed history of a species of this genus, of which the larva lives in mushrooms.[1]

Genus Macrocera, Meig.; named from μακρος, *large*, and κερας, *a horn*—the antennæ being of unusual length. Antennæ projecting, setiform, long, the two radical joints thick: ocelli three, placed on the forehead in the form of a triangle: wings obtuse, incumbent, parallel.

M. *lutea.* Of a uniform ochre-yellow: antennæ above twice the length of the body, brown, yellow at the base: abdomen inclining to brown behind: legs yellow, with brown tarsi. Three lines. This species occurs in the south of England, and eight others are recorded as indigenous to Britain.

* *

Antennæ compressed, sixteen-jointed.

Genus Synapha, Meig. Antennæ projecting, cylindrical, sixteen-jointed? the two lowest joints distinct: eyes rounded: ocelli three, unequal, placed in a line on the forehead: tibiæ unarmed on the sides.

S. *fasciata.* Head and antennæ black: palpi ferruginous: thorax pubescent, shining black; scutellum of a similar colour, small: first four joints of the abdomen shining red, with a black band across their hinder margin, the remainder black: thighs and tibiæ ferruginous, tarsi brown: wings hyaline, the central longitudinal nerve forming an oblong cell behind the cross nerve. One and a half line. Inhabits Germany, but is rare.

Genus Mycetobia, Meig. Antennæ projecting, cylindrical, sixteen-jointed, the two radical joints distinct: eyes kidney-shaped: ocelli three, unequal, approximating, placed on the forehead in the form of a triangle: tibiæ unarmed on the sides.

M. *pallipes.* Black: palpi yellow: antennæ brown, nearly cylindrical, and about the length of the thorax; the latter somewhat pubescent: abdomen rather depressed: halteres and legs bright yellow, the tarsi passing into brown at the apex: wings large, rounded at the apex: and having brownish-black nervures. One and a half line. Occurs in the vicinity of London, and in some other parts of Britain.

Genus Platyura, Meig. Name derived from πλατυς, *broad*, and ουρα, *the tail.* Antennæ projecting, compressed, sixteen-jointed, the two radical joints distinct: eyes rounded: ocelli three, approximating, unequal, placed on the forehead in the form of a triangle: tibiæ unarmed on the sides: abdomen depressed behind.

P. *semirufa.* Head, antennæ, and thorax black; the latter with a narrow arched line of white anteriorly: abdomen yellowish red, passing into brown, the two first segments black: halteres and legs rufous, the tarsi brown: wings nearly hyaline, without spots or bands. Three lines. Found near London, Edinburgh, and in the border counties of Scotland Thirteen other species are natives of Britain.

Genus Gnoriste, Hoff. Antennæ projecting, cylindrical, sixteen-jointed, the two radical joints thick and short: proboscis elongate, bearing the palpi at the apex: ocelli three, unequal, placed on the forehead in the form of a triangle: tibiæ spurred at the apex, the sides spinose.

G. *apicalis.* Head black; antennæ dark brown: proboscis twice the length of the head; the palpi, which are inserted near the apex, small and ferruginous: thorax black, impressed with two deep longitudinal lines, which become obsolete behind the middle: abdomen dark brown, pubescent: halteres yellow: coxæ elongate, the anterior pair ferruginous, the others black: thighs and tibiæ yellow, the tarsi dark brown: wings somewhat clouded, the apex brown. Five lines. Has been found in Prussia, but is rare.

Genus Sciophila, Hoff. Antennæ projecting, some-

[1] *Annales des Sciences Nat.* t. x.

what compressed, sixteen-jointed, the two radical joints distinct: ocelli three, unequal, approximating, placed on the forehead in the form of a triangle: tibiæ with spurs at the apex, and spines on the sides: wings with the intermediate cell small and nearly quadrate.

S. *fimbriata.* Ferruginous; antennæ brown, yellow at the base; anterior part of the head yellow, the forehead brown: thighs ferruginous, tibiæ and tarsi brown: abdomen pubescent, the segments margined behind with black, the hinder extremity likewise black: wings unspotted, hyaline. One two-thirds. This insect, and seven other species of the genus, occur in Britain.

Genus Leia, Meig.; named from λειος, *smooth.* Antennæ projecting, compressed, sixteen-jointed, the two radical joints distinct: eyes oblong: ocelli three, unequal: tibiæ with spurs at the apex, the hinder ones spinous on the sides.

L. *flavicornis.* Ochraceous, as well as the antennæ: ocelli remote: thorax and abdomen somewhat shining: tarsi brown: wings slightly yellowish, with a narrow, somewhat arched, cross band of brown before the apex, slightly increasing in width at the anterior border; and towards the hinder margin of the wing there is a small pale-brown spot placed at the hindermost longitudinal nerve. Two lines. Meig. *Zw.* i. pl. ix. fig. 11, *female.* Inhabits Britain, with four others of the ten described by Meigen as occurring in Europe.

Genus Mycetophila, Meig. Antennæ projecting, compressed, sixteen-jointed, the two radical joints distinct: eyes oblong: ocelli indistinct: tibiæ with spurs at the apex, the hinder ones with spines on the sides.

M. *lineola.* Hypostoma[1] and palpi yellow; antennæ greyish brown, the two radical joints yellow: thorax ochreous above, with three brown lines, the sides of the breast with a mixture of grey: abdomen brown, with yellow incisures: halteres yellow: legs pale yellow, the tarsi brown; hinder thighs black at the apex: wings yellowish, somewhat dusky along the anterior border, and marked with a dark-brown spot near the middle. Two lines. Meig. *Zw.* i. pl. ix. fig. 15. This species occurs in Roxburghshire, near London, and on the continent of Europe. The genus contains thirty species; of these upwards of twenty are included in the entomological catalogues of Britain. The larvæ of several species are found in great numbers in fungi, on the substance of which they feed. The *M. fusca* of Lat. and Meigen seems indeed to have been described by Degeer under the name of *Tipula fungorum.*[2]

Genus Cordyla, Meig. Antennæ projecting, twelve-jointed, the two radical joints distinct: eyes rounded; ocelli wanting: tibiæ with spurs at the apex, but unarmed on the sides.

C. *crassicornis.* Head blackish; antennæ twice the length of the head, compressed when seen from the side, the colour dark brown: thorax grey, the back darker in the middle: abdomen dark brown: halteres and legs bright yellow, the hinder thighs brown at the apex; tarsi brown: wings grey. One and a half. Meig. *Zw.* i. pl. x. fig. 1. Inhabits Austria, England, &c.

f. Lugubri.

Eyes nearly meeting above, and deeply margined: ocelli unequal; antennæ cylindrical: palpi three-jointed: thorax without cross suture: abdomen seven-ringed.

Genus Sciara, Meig. Antennæ porrect, cylindric, pubescent, sixteen-jointed; the two basal joints thickest: eyes deeply emarginate: ocelli unequal: palpi exserted, incurved, three-jointed: wings incumbent, parallel.

S. *Thomæ.* Black; abdomen with a longitudinal line of saffron yellow on each side, consisting of spots in the male, and narrower than in the female; the last has the incisures also yellow: wings smoke coloured, iridescent: halteres and legs piceous: thighs of the fore legs rufescent in both sexes. Four lines. *Tipula Thomæ,* Linn.; *Molobrus Thomæ,* Lat. Occurs at times in tolerable plenty in woods in the south of Scotland, and in many parts of England, generally frequenting umbelliferous plants, in the months of June, July, and August.

g. Latipennes.

Eyes of the male meeting above, those of the female separated and kidney-shaped; ocelli wanting: antennæ cylindrical: palpi four-jointed: proboscis porrect, perpendicular: abdomen eight-ringed: wings very broad.

Genus Simulia, Meig. Antennæ porrect, cylindric, eleven-jointed, the two basal joints distinct: palpi exserted, incurved, cylindric, four-jointed, the basal joint shortest: ocelli wanting: wings broad, incumbent, parallel.

S. *reptans.* Female. Palpi and antennæ brown; hypostoma white; forehead blackish blue; thorax brown, with a bluish play of colour, the anterior part cinereous, with a brown line in the middle, which has a cross streak of brown close to it on each side; the hinder part with an ash-grey play of colour: abdomen dark brown, with pale-yellow hairs at the base, the hinder segment shining bluish grey: thighs brown: tibiæ white, brown at the apex: anterior tarsi deep black, the medial and posterior tarsi brown: halteres pale yellow. One line. *Culex reptans,* Linn.; *Simulium reptans,* Lat. Of pretty frequent occurrence in Britain, and other countries. We have above a dozen indigenous species. These insects bite sharply, and attack various animals.

h. Muscæformes.

Eyes of the male meeting above, in the female separate and round: ocelli three, of equal size: antennæ cylindrical: thorax without a cross suture in the middle.

Genus Scatopse, Geoff. Antennæ projecting, cylindrical, perfoliate, eleven-jointed: eyes kidney-shaped: ocelli three: palpi concealed: legs unarmed.

S. *notata.* Shining black, smooth. The thorax has a white spot on the sides anteriorly: and there is another, crescent-shaped, before the base of the wing, and a similar crescent shaped spot is placed on the sides at the base of the abdomen: halteres black. One and a third line. *Tipula notata,* Linn.; *Tip. latrinarum,* Degeer, vi. 160, pl. xxviii. p. 1–4; *Tipula albipennis,* Fab. Found in England, Scotland, Germany, &c.

The palpi in the preceding genus, as far as perceptible, seem to consist of only a single articulation—a character in which they differ from their congeners. The larvæ are apodal, and live in impure substances. The nymphs are naked and motionless. The perfect insects occur on the trunks of trees, on moist walls, and on flowers, especially those of the *Synantheræ,* of which they suck the nectaries. The species are few in number, and of small size.

Genus Penthetria, Meig. Antennæ projecting, cylindrical, perfoliate, eleven-jointed; eyes oval: ocelli three: palpi standing out, incurved, four jointed: legs unarmed.

P. *holosericea.* Entirely velvet-black, with brown eyes and wings: forehead of the males very narrow, that of

[1] This term is used by Meigen to designate the region of the head lying between the antennæ, the eyes, and the mouth. The same part is named *clypeus* by Fallen.

[2] *Mémoires,* t. vi. pl. 22. fig. 1–13.

the female wide; head in both sexes as wide as the thorax: wings of the male much smaller than those of the female: legs pubescent, without spines, much longer in the male than in the female. Male two and a half, female three and a half lines. Lat. *Gen. Crust.* iv. 267; Meig. *Zw.* i. pl. x. fig. 17, 18. Found in Germany, &c.

GENUS DILOPHUS, Meig.; from δις, *two*, and λοφος, *a comb*. Antennæ projecting, cylindrical, perfoliate, eleven-jointed: palpi standing out, incurved, five-jointed, the third joint dilated at the apex: anterior tibiæ radiated at the apex.

D. *vulgaris*. Shining black: wings of the males hyaline, with blackish marginal nerves; those of the female brown, with the apex hyaline, the nerves with a pale margin, and the stigma blackish. Two and a half lines. Meig. *Zw.* i. pl. xi. fig. 1, *male*. *Tipula febrilis*, Linn. Fab. Lat. Common during spring and summer.

GENUS BIBIO, Geoff. Antennæ projecting, cylindrical, perfoliate, nine-jointed; palpi incurved, cylindrical, five-jointed, first joint very short: ocelli three: anterior tibiæ mucronate at the apex. Meig. i. 309, pl. xi. f. 9–15; Curtis, *B. E.* pl. cxxxviii.

B. *Pomonæ*. Shining black, with pubescence of the same colour: thighs rufous: wings hyaline, the anterior margin fuscescent, marginal nervures and stigma dark brown. Male six, female seven lines. *Tipula Pomonæ*, Fab. Don. ix. 27, pl. ccc.

B. *Marci*. Very like the last, but entirely black; wings of the males hyaline, of the females brown; both have the anterior margin dark brown, with black-brown nervures, and a stigma of the same colour. Five to six lines. ♀ *Tipuli Marci*, Linn.; *Hirtea Marci*, Fab.; ♂ *Tip. brevicornis*, Linn. These two species, which are the largest of the genus, occur not unfrequently in Britain: in the south of Scotland the former is common, and we have often seen large *flocks* of the latter near Edinburgh.

In this genus the sexes differ considerably, which has not seldom led to the males and females being described as distinct species.[1] The larvæ are frequently found in the dung of cattle. They are apodal, but otherwise bear a resemblance to small caterpillars, being furnished with a few hairs directed backwards. They are also believed to change their skins before assuming the nympha state. The perfect insects appear in spring; and, according to the continental naturalists, at two different periods, corresponding to the feasts of St Mark and St John,—a circumstance which has obtained for them the names of *Mouches de St Marc* and *Mouches de St Jean*. Their flight is heavy, and they are sometimes seen in great quantities on fruit trees, to which, however, notwithstanding a vulgar prejudice to the contrary, they are in no way injurious. Meigen describes sixteen European species, and Mr Stephens enumerates fourteen as occurring in Britain. Their manners are curiously detailed by Réaumur.[2]

GENUS ASPISTES, Hoff. Antennæ projecting, eight-jointed, the terminal joint thickened, ovate: ocelli three: anterior tibiæ terminating in a spine.

A. *berolinensis*. Antennæ black, somewhat longer than the thorax, the two lowest joints thickened at the apex, the following short, the terminal one broader, ovate, and excavated in the middle: thorax pitch-black, with an oval spot on the back anteriorly: abdomen pitch-black, pubescent, the hinder extremity brownish red: thighs nearly black; tibiæ and tarsi reddish yellow: wings hyaline, the marginal nervures dark brown, the others pale brown: halteres black. One line. Inhabits Germany, Prussia, &c. One or two other species are said to occur in Britain.

GENUS RHYPHUS, Lat. Antennæ projecting, subulate, sixteen-jointed, the two radical joints distinct: palpi exserted, incurved, four-jointed, the joints unequal, the second clavate: ocelli three, equal: legs unequal: wings parallel, incumbent.

R. *fuscatus*. Antennæ and palpi dark brown; head and thorax cinereous, the latter with three black lines, the central one longest: scutellum grey: abdomen of the males dark brown, with pale incisures, that of the female brownish yellow: halteres whitish: wings somewhat clouded, and having brown nervures, the stigma and a marginal spot fuscous. Male four, female three lines. Meig. *Zw.* i. pl. xi. fig. 18. ♀ Found in Britain, and is common in many parts of Europe.

B. Antennæ consisting of few joints.

FAMILY II.—XYLOPHAGI.

Antennæ projecting, approximating at the base, three-jointed, the third joint eight-ringed: proboscis retracted: ocelli three: abdomen composed of eight segments: halteres uncovered: wings parallel, incumbent; onychii three.

GENUS BERIS, Lat. (Plate CCLI. figures 4 and 4 *a.*) Antennæ with the two radical joints short, third elongate, conical, eight-ringed: scutellum with many rays on the margin. Meig. Curtis. *Brit. Ent.* vii. pl. cccxxxvii.

B. *vallata*. Antennæ dark brown; head and thorax shining black: abdomen reddish yellow, that of the male having two black spots at the base; legs rufous, the hinder half of the tibiæ and the tarsi brown: wings of the female scarcely inclining to brownish, the base and anterior margin yellowish, the stigma dark brown. Two and a half lines. *Stratiomys clavipes*, Fab.; *Beris nigritarsis*, Lat. This species is found pretty frequently throughout the greater part of Britain. We have observed it near Edinburgh, and in Roxburghshire; and it occurs in Essex, Kent and other parts of the south of England. We have ascertained the existence of *B. femoralis*, *B. clavipes*, (Linn.), and *B. chalybeata*, in the south of Scotland; and seven others inhabit the more southern portion of the island.

GENUS XYLOPHAGUS, Meig. Antennæ with the second joint cup-shaped, the third elongate, eight-ringed; proboscis retracted: scutellum unarmed.

X. *ater*. Shining black: first joint of the palpi yellow, second black: thorax of the males entirely shining black, that of the female with three grey vittæ, the lateral ones somewhat abbreviated: anterior legs bright yellow, with the apex of the tarsi brown; hinder legs bright yellow, the apex of the thighs, of the tibiæ and tarsi, brown; halteres yellow. Male five, female six lines. Meig. *Zw.* ii. pl. xii. fig. 14. Lat.; *Empis subulata*, Panz. Apparently the only species of the genus found in Britain.

GENUS CŒNOMYIA, Meig. Antennæ with the radical joint elongate, cylindrical, second cup-shaped, third conical, eight-ringed: scutellum bidentate.

C. *ferruginea*. Rust brown: thorax with two lines of changeable white, which disappear behind the middle: abdomen dark rust brown anteriorly, paler behind; the second segment with a rather large white spot on each side

[1] For example, *Tipula Hortulana* of Linn. is the female of *B. Marci* described above.
[2] *Memoires*, t. v. p. 55, et pl. vii.

behind, the two following with a similar spot, but united by a narrow white line; belly rust yellow, the hinder margins, with the exception of the first, whitish; legs ferruginous: halteres bright yellow: wings brownish yellow, with ferruginous nerves. Six to seven lines. *Tabanus bidentatus*, Fab. Gmel. Lat.; *Sicus ferrugineus*, Fallen. Not unfrequent in Germany and other continental countries in the months of June and July. It has not hitherto been observed in Britain.

FAMILY III.—TABANII.

Antennæ projecting, approximating at the base, three-jointed; third joint from four to eight-ringed, or six-jointed: proboscis and palpi standing out: abdomen consisting of seven segments: halteres half covered: wings divaricating: onychii three.

a. Antennæ three-jointed.

Genus Pangonia, Fab. Antennæ with the basal joint cylindric, second cup-shaped, third elongate, subulate, eight-ringed: ocelli three: proboscis elongate, exserted: wings spreading.

P. *ferruginea*. Antennæ black, the second joint and base of the third yellow; proboscis black, the length of the thorax; the latter thickly covered with brownish-yellow pubescence: abdomen with similar pubescence, and marked with black spots on the back, the segments margined behind with whitish: belly rust-brown: wing-scales, halteres, and legs bright brown; thighs black: wings brownish. Eight lines. Lat. *Gen. Crust.* iv. 282. Inhabits Portugal. The genus contains six European species, none of which appear to occur in Britain.

Genus Silvius, Meig. Antennæ with the radical joint cylindrical, second cup-shaped, third subulate, five-ringed: ocelli three: palpi standing out, two-jointed, pilose, the second joint cylindrical in the male, conical in the female.

S. *Vituli*. Antennæ ochre-yellow, the apex black; hypostoma bright yellow; forehead of a similar colour, with a shining black callosity anteriorly in the female; palpi yellow, the apex black in the male: thorax yellow with a brown play of colour, pubescent: abdomen pubescent, yellow: wing-scales and halteres yellow, the knob of the latter whitish: wings with microscopic hairs, somewhat greyish, with the anterior margin yellow; legs yellow, with brown tarsi. Five to six lines. *Tabanus Vituli*, Fab.; *Tabanus Italicus*, Fab. This insect occurs on the continent, but we have no knowledge of its precise localities.

Genus Tabanus, Linn. (Plate CCLI. figures 5 and 5 *a*). Antennæ with the basal joint cylindric, second cup-shaped, third compressed, the lowest ring very large and crescent-shaped at the base: ocelli wanting: palpi exserted, capitate in the male, subulate in the female: wings spreading.

T. *bovinus*. Antennæ black, reddish brown at the base: hypostoma, palpi, and forehead bright greyish yellow; the latter in the female with a black line, which terminates beneath in a shining black roundish callosity; eyes green during life: thorax dark brown, with yellowish hair, sometimes inclining to slate-colour, and having dark lines on the back: abdomen dark brown, with a rather wide reddish-yellow cross band on the hinder edge of the segments, and a row of bright yellow triangular spots down the middle: belly yellowish grey, darker behind the incisures, with rather large nearly triangular spots of black, and near these an oblique black line: thighs and tarsi dark brown; tibiæ bright yellow, the apex brownish: wing-scales and halteres brown, the apex of the latter pale; wings brownish, the anterior margin inclining to yellow. One inch. Linn.; Degeer, vi. 88. i. pl. xii. fig. 6–14. Common on the continent. It is not quite so plentiful in Britain, especially in Scotland, where we have seen it only on a few occasions in the northern and middle counties. We have taken it by the banks of Loch Katrine, and in Sutherland. Eighteen kinds of Tabani inhabit Britain, and upwards of twice that number are known as European. Besides *T. bovinus*, we are not acquainted with any other Scotch species except *T. tropicus* and *T. autumnalis*.

Latreille, Lepelletier and Serville, Meigen, Wiedemann, Macquart, and the late Palisot de Beauvis, have cleared away many of the difficulties which encumbered the systematic study of this and the allied genera; but their natural history, properly so called, has scarcely received any accession since the days of Degeer. It is to that great observer that we owe our knowledge of the manners and metamorphoses of the species above described, the only one in fact of which we have any detailed account. *T. maroccanus* is extremely troublesome to camels in the north of Africa. M. Defontaines has frequently observed their bodies entirely covered by these insects. The species occurs also in Portugal.

Genus Chrysops, Meig. (Plate CCLI. figures 6 and 6 *a*). Named from χϱυσος, *gold*, and ὄψ, *the eye*, which is usually very brilliant during life. Antennæ cylindrical, three-jointed, two basal joints equal, third longer, five-ringed: palpi exserted, two-jointed, pilose, the second joint conic: ocelli three: wings spreading.

C. *cœcutiens*. Male. Black; the eyes with two dark purple bands; the uppermost interrupted; hypostoma yellow, with large dark spots which nearly conceal the ground colour: forehead black: thorax with reddish pubescence on the sides and beneath: abdomen black, with a rufous spot on each side of the second segment; under side black brown, the two basal segments yellow, having a brown line in the middle: antennæ, palpi, legs, and halteres black: wings almost entirely brown; in the middle there is a small light-coloured spot; at the hinder margin, before the apex, a nearly uncoloured triangle, and not far from the base a pale mark.

The thorax of the female is lined with cinereous; the first segment of the abdomen has two yellow spots, the second is yellow, with two dark lines in the centre, enclosing a triangular mark of yellow behind: wings whitish; the base, anterior margin, a broad band rather behind the middle, and an apical spot, brown. Four lines. *Tabanus cœcutiens*, Linn.

Frequent in most countries of Europe. In Scotland it is rather scarce, but has been taken occasionally in Dumfriesshire, Roxburghshire, and elsewhere.

Genus Hæmatopota, Meig.; named from αἷμα, *blood*, and ποτης, *drinker*. Antennæ three-jointed, the second joint cup-shaped, third subulate, four-ringed: palpi exserted, two-jointed, second joint conic: ocelli wanting: wings parallel, deflexed. Meig. ii. 76. pl. xiv. f. 8–16.

H. *pluvialis*. Eyes greenish, with waved purple-brown bands: palpi and hypostoma light grey; antennæ scarcely longer than the head; first joint thick, oblong, shining-black, pubescent; thorax blackish, with whitish lines, the two next the middle having a white spot in the centre; sides of the breast light grey, somewhat pubescent: scutellum blackish, sometimes cinereous over the middle: abdomen blackish brown, with whitish incisures and a cinereous line down the back; on the third and following segments on each side of this line there is a round cinereous spot; in the males the three first segments are somewhat testaceous on the sides: belly brownish grey: thighs cinereous: anterior tibiæ yellow at the base, the apex, together with the tarsi, black brown; posterior tibiæ yellow, with three brown rings, one in the middle and another at

each end; the tarsi black brown, with the first joint yellowish: halteres yellowish, having a brown spot on the knob: wings brownish-cinereous, with numerous waved lines of white, and a dark-brown marginal streak. Four to four and a half lines. Meig. ii. 78, pl. xiv. f. 16. *Tabanus pluvialis*, Linn. Very plentiful throughout Britain. This insect is known in Scotland by the name of *Cleg*, and is very troublesome during the heat of summer both to man and beast, particularly horses.

b. Antennæ six-jointed.

GENUS HEXATOMA, Meig.; named from ἕξ, *six*, and τόμος, *section*, in allusion to the number of joints in the antennæ. Antennæ six-jointed; the first and third joints elongate: palpi exserted, two-jointed; second joint capitate (in the male) or conical (in the female): ocelli wanting: wings parallel, deflexed. Meig. ii. 83, pl. xiv. f. 17–24. *Heptatoma*, Lat. *Gen. Crust.* iv. 284.

H. *bimaculata*. Hypostoma of the males shining-black, with yellowish hair; that of the female light grey above and yellow beneath; thorax blackish, with rufous pubescence: abdomen of the males black, the pubescence of the two basal segments brownish yellow; on the belly these segments are bluish white at the sides and blackish in the middle; the following black, with three pair of bluish-white transverse streaks: abdomen of the female black, the base with brownish-yellow pubescence, and the second segment with bluish-white lateral spots: feet black brown: wings vitreous. Six lines. *Tabanus pellucens*, Fab. A rare species, which has not yet been detected in Britain.

FAMILY IV.—LEPTIDES.

Antennæ porrect, approximating at the base, three-jointed; third joint without rings: proboscis and palpi exserted: ocelli three: abdomen consisting of seven segments: halteres uncovered: onychii three.

GENUS LEPTIS, Fab. Antennæ with the first joint cylindric, second cup-shaped, third conic with an apical seta: palpi pilose, the second joint elongate: ocelli three, vertical: wings spreading.

L. *aurata*. Male. Hypostoma blackish grey; antennæ dark brown; thorax and abdomen thickly covered with shining golden hairs: halteres, thighs, and tarsi dark brown; tibiæ testaceous: wings pale brown, with the stigma reddish brown.

Female. Hypostoma and forehead dark grey, the latter broad: thorax and abdomen thickly clothed with light-yellow hairs; sides of the breast black; wings nearly hyaline, scarcely tinged with brown, the stigma reddish brown: halteres and legs as in the male. Three to four lines. *Rhagio atratus*, Fab. Lat.; *Rh. tomentosus*, Fab. In marshy meadows in May, common. This genus, as constituted by Meigen, contains twenty-two species; but more recent writers have separated it into two genera, corresponding to his sectional divisions. Nearly all of these inhabit Britain, and some are very abundant, particularly *L. scolopacea* and *L. tringaria*.

GENUS ATHERIX, Meig. (Plate CCLI. figures 7 and 7 *a*.) Antennæ with the terminal joint ovate, having a naked dorsal seta at the base: palpi standing out, pilose, incurved: ocelli three, vertical: wings spreading.

A. *Ibis*. Hypostoma and forehead bright yellow; the latter in the female yellowish with a brown vitta; thorax pubescent, yellowish brown, with broad lines of dark brown along the back; scutellum brown: abdomen of the males conical; the first segment dark brown, the following ferruginous with the hinder margin bright yellow, and marked with three black spots, one on the back and another on each side; on the last segments these spots run together; belly yellow: abdomen of the females ash-grey, the segments with a black band anteriorly, the hinder margin white; belly ash-grey: legs ferruginous, the tarsi brown at the apex: halteres yellow, the knob brown: wings hyaline, with irregular cross bands of reddish brown, which are paler in the female. Male four, female five lines. Curtis, *Brit. Ent.* i. 26; *Rhagio Ibis*, Fab.; ♀ *Atherix maculatus*, Lat.; *Anthrax Titanus*, Fab. Mr Curtis states that there are at present but two species of this genus recorded as natives of Britain, although twelve are enumerated as European. The species described appears to be everywhere rare. The male and female were placed by Fabricius in different genera.

GENUS CLINOCERA, Meig. Antennæ remote, the lower joints spherical, the third conical with an incurved terminal seta: ocelli three, placed on the forehead: wings incumbent, parallel.

C. *nigra*. Head black; body dull black; thorax with three darker lines; legs long, slender, and black: halteres black, uncovered: wings hyaline. Two lines. Found in Germany and elsewhere.

FAMILY V.—XYLOTOMÆ.

Antennæ projecting, approximating at the base, three-jointed, the third joint without rings: proboscis concealed: ocelli three: abdomen seven-ringed, conical: halteres uncovered: wings spreading: onychii two.

GENUS THEREVA, Lat. Antennæ with the radical joint cylindrical, second cup-shaped, third conical: proboscis retracted: ocelli three: wings spreading.

T. *fulva*. Ferruginous, with pubescence of a similar colour, intermixed with black hairs on the thorax; two first joints of the antennæ ferruginous, the third dark brown: on the forehead of the females is the usual shining black spot, and the hinder extremity of the abdomen is likewise black: thighs and tarsi brown; tibiæ ferruginous: halteres yellow: wings nearly hyaline, the anterior border yellowish. Four to five lines. This insect is of not unfrequent occurrence in the south of Scotland, where *T. anilis* and *T. plebeia* are likewise found. The former is distinguished by its reddish thorax, and abdomen of a silvery-white or grey colour. It is generally seen sitting upon sand, but flies off suddenly if an attempt is made to seize it. Meigen mentions twenty species. Britain produces about one half of that number.

FAMILY VI.—MYDASII.

Antennæ projecting, five-jointed, the joints without rings, the terminal one club-shaped.

GENUS MYDAS, Lat. (Plate CCLI. figures 8 *a* and 8 *b*.) Antennæ with the two lowest joints small, the following cylindrical, the terminal one clavate. Proboscis exserted.

M. *lusitanicus*. Entirely black, except the hinder edge of the abdominal segments, which are yellowish white: beard and mystax[1] white: the sides of the thorax and two first segments of the abdomen are beset with long white hairs, and the back of the abdomen and legs with short white pubescence: wings yellowish. Eight lines. Inhabits Germany, Portugal, &c. Another species, named

[1] This term is applied to a semicircle of bristles or hairs placed over the mouth.

M. filatus, is found in America. It is figured by Drury.[1] Brazil produces one above two inches long.

FAMILY VII.—BOMBYLIARII.

Antennæ projecting, three-jointed; third joint without rings: hypostoma beardless: forehead flat: (proboscis retracted or somewhat projecting) ocelli three: abdomen consisting of seven rings, cylindric or elliptical: wings spreading: halteres uncovered.

Genus Hirmoneura, Wied. Antennæ remote, the joints sub-globose, equal, the third with a terminal style: ocelli three, the anterior one remote: proboscis retracted and concealed.

H. *obscura*. Hypostoma ochre yellow; forehead cinereous with blackish hairs: thorax black, with yellowish hairs on the sides, those on the breast more inclining to grey: abdomen with the lateral edges yellow, the upper side with yellowish grey pubescence, the apex of the segments slate grey; belly yellowish, and covered with pubescence similar to that on the breast: wings brownish grey, especially at the anterior margin: halteres dark brown: legs ochre yellow, the tibiæ and tarsi a little darker: extremity of the abdomen with two short truncated styles. Seven and a half lines. Found in Dalmatia.

Genus Fallenia, Meig. Antennæ remote, the joints sub-globose, the last with an elongate terminal style: proboscis the length of the body, and bent beneath the breast.

F. *caucasica*. Head and thorax covered with whitish hair; eyes of a metallic hue: abdomen nearly orbicular, with blackish pubescence; the first segment wide, with grey pubescence, the following fringed with whitish grey upon the hinder edge; the anus ferruginous: wings yellowish: legs brownish grey, with rather indistinct grey hairs. Five to five and a half lines. *Volucella caucasica*, Wied. *Zool. Mag.* i. 2, 7. Found in Russia and elsewhere, but appears to be scarce. There is only one other species, *F. fasciata*, Fab. a native of Italy.

Genus Stygia, Meig.[2] Antennæ approximating, the first joint dilated at the apex, and obliquely truncate, second cup-shaped, third conical: head sub-globose; eyes kidney-shaped: proboscis retracted.

S. *Belzebub*. Male. Hypostoma and forehead black, the last having a tendency to pass into grey over the antennæ: thorax wholly shining black, with pubescence of the same colour: abdomen shining black, the hinder margin of the segments (with the exception of the first) narrowly edged with yellow; the pubescence on the sides of the first segment whitish, and on the following black: belly entirely black: wing-scales black, fringed with white hair: stalk of the halteres brown, the knob pale yellow: legs black. Five to six lines. *Anthrax Belzebub*, Fab. This fly is found in France, Italy, Hungary, England, and in most other parts of Europe.

Genus Anthrax, Scop. (Plate CCLI. figures 9 and 9 *a.*). Antennæ distant, the first joint cylindrical, second cup-shaped, third sub-globose, with an elongate or conical style; eyes kidney-shaped: proboscis retracted or very slightly produced.

A. *flava*. Hypostoma with bright yellow pubescence; forehead black, with short rufous hairs, which are mingled with black ones: antennæ black: thorax and abdomen covered throughout with long reddish shining hairs, the anus having pale yellow hairs, and three black tufts: stalk of the halteres brown, the knob yellow: wings hyaline, with a yellowish-brown streak along the anterior edge, and the base with a pectinated mark of black: wing-scales brownish yellow: legs black; thighs and tibiæ sprinkled with yellow. Seven lines. *Anthrax hottentotta*, Fab.; *Musca hottentotta*, Don. xiv. 69, pl. ccccxciv. Inhabits England, France, and Holland, occurring not unfrequently. This genus, as constituted by Meigen, contains about sixty species, a small proportion of which has yet been detected in Britain. We know little of their history or transformations.

Genus Mulio, Lat. Antennæ distant, the first joint short and cylindrical, second cup-shaped, third conical, acute; eyes elliptical: proboscis standing out, horizontal.

M. *infuscatus*. Hypostoma with ash-grey hairs; the forehead with dark-brown hairs; proboscis as long as the head: thorax dark brown, ash-grey on the sides: abdomen flat and arched, with ferruginous hairs, the incisures beset with numerous black bristles; halteres brown, the knob almost entirely white; wings light brown, the apex hyaline: legs yellow and glistening; the tarsi brown. Three and a half lines. Found in Provence by M. Baumhauer.

Genus Bombylius, Linn. (Plate CCLI. figures 10 and 10 *a.*) Antennæ approximating, the first joint cylindrical, second cup-shaped, third elongate and compressed; proboscis standing out, longer than the head: body woolly.

B. *minor*. Beard whitish; mystax reddish: the sides covered with black hairs: forehead of the females with reddish hair: antennæ and proboscis black: ground colour of the body deep black, the whole surface covered with rufous hairs: halteres dark brown; wings somewhat greyish, the base and anterior margin more or less rufescent. Four lines; the proboscis from two and a half to three lines. Fab. Linn. Found in several parts of England: we have often observed it in considerable abundance on the sides of Arthur's Seat, and in the fields to the south of Duddingston. About six other species occur in Britain; and although the appearance of these is very familiar, naturalists in truth know little or nothing of their transformations. Latreille supposes that their larvæ are parasitical. Nearly fifty European species are described by systematic authors.

Genus Phthiria, Lat. Antennæ approximating, the two lower joints short and equal, the third elongate, spindle-shaped, compressed: proboscis standing out, horizontal, elongate: palpi clavate.

P. *minuta*. Male. Hypostoma and forehead black, and covered with black hairs: body wholly deep black, with soft and rather long black hairs: wings smoke-brown, the stigma brown: halteres and legs black.

Female. Hypostoma white; the forehead blackish, the margin of the eyes white: body black, with traces of white hairs; scutellum yellow, having a dark-brown streak along the sides: under side of the breast whitish; halteres brown above, white beneath: wings brown, but considerably paler than those of the male: legs black. One and a half line. Lat.; *Volucella minuta*, Fab. Occurs, along with five other species, on the continent of Europe.

Genus Geron, Hoff. Antennæ approximating, the first joint elongate, cylindrical, second cup-shaped, third

[1] *Illustrations*, vol. i. tab. 44, fig. 1.

[2] The name of this genus is defective, in as far as it has been already applied to a lepidopterous genus. Meigen has since altered it to *Lomatia*, which is scarcely more fortunate, as it also has been previously applied by Mr Brown to a genus in botany of the family of Proteaceæ. Latreille has altered the original designation to *Stygides*.

cylindric-subulate: proboscis standing out, horizontal, elongate.

G. *gibbosus.* Hypostoma and forehead white; antennæ black; thorax whitish grey, with two wide lines of brownish black down the back: scutellum and abdomen black: halteres white; wings hyaline, inclining to pale yellow at the anterior border: legs dark grey. Two and a half lines. Has been found in Bucharia by M. Baumhauer in the month of July.

Genus Usia, Lat. Antennæ approximating, the first joint sub-cylindrical, very short; second cup-shaped; third spindle-shaped, elongate, obtuse: proboscis standing out, elongate, horizontal, acute.

U. *ænea.* Dark brassy: forehead white anteriorly, greyish behind, with a shining black vitta; hinder part of the head cinereous, and marked with a shining black streak in the centre: wing-scales and halteres white: abdomen finely pubescent, wide, flat, and arched; the belly whitish yellow, marked with black cross bands which are abbreviated at the sides: wings hyaline, with a yellow base and a large black spot near the middle of the anterior margin: legs black, with a metallic lustre. Two and a half to three lines. Lat. *Gen. Crust.* iv. 315. Found near Bourdeaux and elsewhere.

Genus Ploas, Fab. Antennæ approximating, the first joint very thick and conical, second cup-shaped, third spindle-shaped, and furnished with a jointed style at the apex; proboscis standing out, horizontal, the length of the head.

P. *grisea.* Colour varying from black to slate-grey: thorax marked with four grey lines, the two in the middle united anteriorly: halteres white: abdomen griseous: wings brownish at the base and anterior margin. Three and a half lines. *Bombylius griseus,* Fab. Inhabits Germany, Spain, &c.

Genus Cyllenia, Lat. Antennæ approximating, the first joint cylindrical, second very short, cup-shaped, third conical with a simple style at its apex: eyes oval: proboscis somewhat standing out, horizontal.

C. *maculata.* Antennæ with the radical joint brownish grey, second white, the third black: forehead black, the margin of the eyes white: thorax black, with yellowish-grey pubescence, mixed with long black hairs: abdomen with the first segment brown, the following pale yellow anteriorly, brown behind, with reddish-yellow hair and long black ones intermixed; on each segment are two longitudinal lines of black, diverging behind, and a black spot: halteres pale yellow above, brown beneath: legs black, covered with matted hair of a ferruginous colour: wings pale brown at the anterior edge, and sprinkled over the surface with dark-brown spots. In the male the hinder thighs are much thicker than in the female. Three to four lines. Lat. *Gen. Crust.* iv. 312. The species described is the only one belonging to the genus. It appears to be more frequent in France than in any other European country.

Genus Toxophora, Meig. Antennæ longer than the head, approximating, the two lower joints cylindrical, the third conical; proboscis standing out, arched, one half longer than the head; the palpi slender, cylindrical, bent and acute.

T. *maculata.* Hypostoma white, the hinder part of the head of a similar colour; thorax black, covered with a sulphur-coloured down on the sides and back: abdomen clothed in a similar manner, and having two rows of naked black spots down the back: legs black, with white down, the tibiæ somewhat bristly: halteres white, uncovered: wings hyaline, the anterior margin and the base yellowish. Four lines. This rare fly has been found in the south of France and in Russia. It appears to have been formerly described by Villers under the title of *Asilus fasciculatus.*[1] It was brought from Syria by Labillardière, and is justly admired as a beautiful and interesting species.

The genus is widely distributed, and probably requires subdivision. We have received species from Brazil; Meigen Le Conte has taken it in the United States; Wiedemann describes a species from Java; and *Bombylius cupreus* of Fab. which is now regarded as a Toxophora, is native to Cayenne.

FAMILY VIII.—ASILICI.

Antennæ projecting, approximating at the base, turned upwards, three-jointed; the third joint without rings: hypostoma with a mystax: forehead depressed: proboscis projecting horizontally, short: abdomen consisting of seven segments: halteres uncovered: wings parallel, incumbent.

a. Tarsi with two onychii.

Genus Dioctria, Meig. Antennæ inserted into a frontal tubercle; first joint cylindric, second shorter, somewhat cup-shaped; third elongate, compressed, the apex with a blunt two-jointed style: proboscis exserted, short, nearly horizontal: hinder legs straight, ciliated beneath: wings incumbent.

D. *rufipes.* Shining black: hypostoma bright brass-yellow, shining: on the thorax are two changeable white lines, which, however, are scarcely observable in the males; the sides of the thorax with silvery streaks: halteres yellow: legs rufous, the hinder pair dark brown: wings hyaline. Six to seven lines. *Asilus rufipes,* Degeer. Not a rare insect throughout England: in Scotland it is far from scarce, and *D. lateralis* frequently occurs in company with it. Meigen describes twenty-eight species, eleven of which have been detected in Britain.

Genus Dasypogon, Meig. (Plate CCLI. figures 11 and 11 *a*). Named from δασυς, *hairy,* and πωγων, *a beard.* Antennæ with the two lower joints sub-cylindric, equal, third elongate, compressed, somewhat spindle-shaped, the apex with a short two-jointed style: proboscis horizontal, the length of the head: tibiæ straight.

D. *ruficornis.* Thickly pubescent: antennæ ferruginous, black at the base; mystax ferruginous, the forehead dark brown: thorax shining brownish black, with yellowish-grey spots, and having white hairs anteriorly: scutellum black: abdomen deep black, shining, the hinder half of the second segment and the whole of the third and fourth dull ferruginous, the fifth in the female with a ferruginous margin behind: belly shining black; legs very hairy, dark brown, the tarsi reddish brown: halteres brown, with a yellow knob. Seven to eight lines. *Asilus ruficornis,* Fab.; Meig. *Zw.* ii. pl. xx. fig. 11. This insect occurs in France. The genus contains forty-four European species, only two of which, viz. *D. punctatus* and *D. brevirostris* (Curtis, *B.E.* fol. 153), have been noticed in Britain.

Genus Laphria, Fab. Antennæ with the radical joint cylindric, second cup-shaped, third clavate, obtuse: proboscis standing out, horizontal: tibiæ arched.

L. *gibbosa.* Beard pale-yellow, with a brownish play of colour: thorax black, with reddish-brown hairs: three first segments of the abdomen shining black, the three following clothed with whitish-yellow down; the seventh black, retracted: belly and legs black, the latter with brown pubescence: nervures of the wings margined with

[1] *Entom. Lin.* iii. pl. 10, fig. 31.

yellowish brown: halteres black. Ten lines. *Laphria gibbosa*, Fab.; *Asilus gibbosus*, Fab. Found in various parts of Europe. *L. nigra* (Curtis, *B. E.* fol. 97) is the only species of the genus, which contains thirty-two different kinds, satisfactorily ascertained to inhabit Britain. It has been found in Darent Wood, Kent, in the vicinity of London, and at Coombe Wood.

Genus Asilus, Linn. Antennæ with the basal joint cylindric, second cup-shaped, third subulate, compressed, having a setiform apical style: proboscis exserted, horizontal: tibiæ straight, spinulose.

A. *crabroniformis*. Head yellow: two basal joints of the antennæ rufous, third brown: thorax rufous, with two brown dorsal lines, which are usually obsolete, behind: scutellum brown: three basal segments of the abdomen deep black, the second incisure with a white spot on each side; the remaining segments rufous, with a fine glistening lustre; that of the female bent downwards and terminating in a black style: legs rufous, with brownish thighs: halteres brownish yellow: wings pale yellow, the hinder margin spotted with fuscous. One inch nearly: the male rather less. Meig. ii. 309; Linn. *Fauna Suec.* 1908. Occurs throughout Europe, and in some countries of Asia. The genus is extensive (containing nearly sixty European species), and a considerable number inhabit Britain,—some of them being rather common. *A. opacus* abounds in several parts of Scotland. All the species are carnivorous, and prey upon other Diptera. They even attack hymenopterous insects. Their flight is rapid, and frequently attended by a buzzing sound. They occur in woods and various other places, chiefly in autumn, or the end of summer. Their structure and metamorphoses have been illustrated by Frisch,[1] Degeer,[2] and Marcel de Serres.[3] The larvæ live under ground.

b. Tarsi without onychii.

Genus Leptogaster, Meig. Antennæ with the two lowest joints short, cylindrical, equal; third conical, with the apex pilose: proboscis horizontal, short.

L. *Pallasii*. Naked: thorax slate-grey, black when seen in certain directions; sides of the breast whitish: first segment of the abdomen very small; the last nearly club-shaped, all of them margined with light grey: legs pale yellow, with a ring on the thighs, the apex of the tibiæ and the tarsi brown: hinder legs much longer than the anterior ones, club-shaped, with a ring near the apex: halteres pale: wings with the lower half brown, the remainder hyaline. Four and a half lines. Found in the south of Russia. It is rare.

FAMILY IX.—HYBOTINÆ.

Antennæ projecting, approximating at the base, three-jointed: the first two joints united so as to form one, the third without rings: hypostoma beardless, flat: forehead flat: proboscis projecting horizontally, short: thorax much arched: abdomen slender, consisting of seven rings: halteres uncovered: wings parallel, incumbent.

Genus Hybos, Fab. Antennæ with the two lowest joints united, cylindrical; the third conical, with a pubescent seta at the apex: hinder thighs thickened.

H. *funebris*. Black, with a whitish hypostoma, and pale yellow halteres: thorax with a white play of colour behind: wings with a dark-brown stigma. Two lines. *Asilus culiciformis*, Fab. Common everywhere in hedges and among grass. Four other species in addition to the above are indigenous to Britain.

Genus Ocydromia, Hoff. (Plate CCLI. figures 12 and 12 *a.*) Antennæ with two lowest joints united, cylindrical; third lenticular, bearing a seta at the apex: proboscis sub-exserted, horizontal: all the legs simple.

O. *flavipes*. Antennæ dark brown; palpi yellow: thorax and abdomen entirely black: halteres yellow: legs yellow, all the tarsi brown; the hinder coxæ, the apex of the hinder thighs, and the tibiæ, are likewise brown: wings somewhat brownish. Three lines. Found in England and on the continent.

Genus Oedalea. Antennæ with the first joint cylindrical, short; second cup-shaped, third elongate, conic, compressed; proboscis short and horizontal: hinder thighs thickened and spinose beneath.

O. *minuta*. Body black, finely pubescent, shining: halteres brown: legs pale reddish yellow; in the anterior pair the tibiæ and tarsi are brown, and in the hinder pair the tarsi only are of that colour: wings brownish, with a long brown stigma. One and a half line. *Empis minuta*, Fallen. Found in Britain, France, &c.

FAMILY X.—EMPIDIÆ.

Antennæ porrect, approximating at the base, three-jointed, the third joint without rings, and having a style or a seta at the apex: hypostoma beardless: ocelli three: proboscis exserted, very perpendicular, with incurved palpi: abdomen consisting of seven segments: wings parallel, incumbent: onychii two. Meig. iii. 1.

Genus Hilara, Meig. (Plate CCLI. figures 13 and 13 *a.*) Antennæ with the basal joint cylindric; second cup-shaped, third subulate, compressed, the apex with a two-jointed style: proboscis thick, shorter than the head: wings incumbent, parallel, with an oblique transverse nervure at the apex. Meig. *Zw.* iii. pl. xxii. f. 1–5.

H. *cilipes*. Dusky black, antennæ reddish brown: wings fuscous; halteres whitish; the anterior metatarsus of the male dilated in an elliptical form, and fringed on the external margin with long hairs. Two lines. Meig. *Zw.* iii. 3, pl. xxii. fig. 3; Curtis, *B. E.* 130. Found near London. Upwards of twenty species belong to the genus, and nearly all of them inhabit Britain.

Genus Brachystoma, Meig. Antennæ with the first joint cylindric, second cup-shaped, third conic, with a very long terminal seta: proboscis the length of the head: wings incumbent, parallel.

B. *vesiculosa*. Hypostoma greyish white; forehead narrow, black: antennæ as long as the head, black; the two first joints of equal length, the third with a long apical seta bent downwards: proboscis perpendicular, nearly as long as the head: thorax shining black, cinereous on the sides: scutellum very small: abdomen cylindrical, black; the seventh segment very much inflated, pellucid, waxen yellow: halteres white: wings hyaline, with a scarcely perceptible pale marginal streak: coxæ cinereous, short; thighs ferruginous; tibiæ at the base, and the tarsi, brown. Two and a half lines. *Baccha vesiculosa*, Fab. Inhabits Britain and the continent of Europe.

Genus Gloma, Meig. Antennæ with the first joint cylindric, very slender, second cup-shaped; third globose, with an apical seta: proboscis the length of the head, thick.

G. *fuscipennis*. Antennæ black; thorax of the same colour, pubescent: abdomen pubescent, black brown, with yellowish incisures: halteres brown: wings brown, with a dark marginal streak; legs pubescent, brown; all the thighs

[1] In his work on the *Insects of Germany*.

[2] *Mémoires*, t. vi.

[3] *Annales du Mus. d'Hist. Nat.* t. iv. p. 361

and the hinder tibiæ with a groove on both sides; the hinder legs as long as the anterior ones. Two lines. Meig. *Zw.* iii. pl. xxii. fig. 11. Inhabits England, but is very scarce.

GENUS EMPIS, Linn. Antennæ with the basal joint cylindric, second cup-shaped, third conic, compressed, the apex with a two-jointed style: proboscis perpendicular or bent inwards, longer than the head, slender: wings with a transverse nervure at the apex, incumbent, parallel. Meig. *Zw.* iii. 15, pl. xxii. fig. 13–20; Curtis, *B. E.* pl. xviii.

E. *tessellata.* Palpi, antennæ, and proboscis black, the latter as long as the head and thorax: hypostoma and forehead cinereous; thorax of the same colour, bristly, with three dorsal lines black, the central one narrowest: abdomen hairy, cinereous, with a line down the back, and the hinder margin of the segments blackish; when seen in another direction both colours change, the black becoming grey and the grey black: halteres yellowish: wings brown, ferruginous at the base: legs black, the tibiæ testaceous, shining. Five to six lines. Meig. Fab. *E. livida*, Fab. var. Common on flowers, during summer, in England and Scotland, and most parts of Europe: it has been likewise taken by Pallas in Tauria. Twenty-eight species of Empis occur in Britain, and nearly double that number are known to entomologists. Their early states have not been well determined. In the perfect state they prey upon other flies.

GENUS RHAMPHOMYIA, Hoff. Antennæ with the radical joint cylindric, second cup-shaped, third conic, compressed, the apex with a two-jointed style: proboscis perpendicular or bent inwards, slender: wings incumbent, parallel, the transverse nervure at the apex wanting. Meig. *Zw.* iii. 42.

R. *longipes.* Deep shining black, as well as the legs: proboscis twice the length of the head, slender: halteres dark brown: wings hyaline, with a scarcely perceptible stigma: in the males the hinder legs are stout, elongate, and pubescent; the hinder tibiæ somewhat clavate, and the first joint of the tarsi distinctly thickened: in the female the anterior legs are simple. Found in summer, but is rare.

FAMILY XI.—TACHYDROMIÆ.

Antennæ porrect, approximating at the base, two-jointed, with an apical seta: ocelli three: proboscis short, perpendicular: palpi incumbent on the proboscis: abdomen consisting of seven segments: onychii two.

GENUS HEMERODROMIA, Hoff. (Plate CCLI. figures 14 and 14 *a*). Antennæ with the first joint cylindric, second ovate, the apex supporting a seta: proboscis short and perpendicular, with incumbent palpi, which are subulate or cylindric: anterior coxæ elongate: wings incumbent parallel. Meig. *Zw.* iii. 61, pl. xxiii. fig. 5–15.

H. *monostigma.* Yellowish white: forehead cinereous: on the thorax are two cinereous vittæ, which anteriorly are drawn into two black lines: along the back of the abdomen runs a black line, which is notched or sinuated on both sides: the fifth joint of the tarsi is black; wings hyaline, with a marginal spot of black. Two lines. Meig. *Zw.* iii. pl. xxiii. fig. 6. Found in the south of England and elsewhere.

GENUS TACHYDROMIA, Meig. *Sicus*, Lat. Antennæ with the first joint cylindric, second ovate or oblong, with a terminal seta: the anterior or intermediate thighs thickened: wings incumbent. Meig. *Zw.* iii. pl. xxiii. fig. 16–24.

T. *fasciata.* Palpi yellow, proboscis black; hypostoma white; forehead cinereous; antennæ black, with the basal joint yellow: thorax cinereous: abdomen shining black, with a broad cinereous ring, interrupted in the middle, at the base of each segment: halteres bright yellow: legs rufous, the tarsi black at the apex: wings yellowish. Two lines. Meig. *Zw.* iii. pl. xxiii. fig. 22. Has been taken by Dr Leach in England, where thirty-three other species occur. Few of these have been ascertained to inhabit Scotland. *T. minuta*, however, has lately been found near Edinburgh. There are about sixty species in Europe.

GENUS DRAPETIS, Meig. Antennæ with the first joint cylindric, second lenticular, with a seta at the apex: proboscis scarcely exserted, very short, perpendicular, covered by the palpi: wings incumbent, parallel. Meig. *Zw.* iii. pl. xxiii. fig. 25–28.

D. *exilis.* Head black, nearly round; antennæ black: thorax shining black, without a transverse suture above: abdomen of the males entirely shining black, rather long, nearly cylindric; that of the female more oval, pointed, reddish yellow above, with a black transverse band at the hinder margin of the segments, entirely ferruginous yellow beneath: thighs somewhat thickened, black; tibiæ brown, unarmed; tarsi yellow: halteres black: wings hyaline. Male half a line, female three fourths of a line. Said to be common in hedges during the months of August and September, in various parts of the continent.

FAMILY XII.—INFLATÆ.

Antennæ very minute, two-jointed: head almost entirely occupied by the eyes: ocelli three: abdomen very thick, consisting of five segments: onychii three.

GENUS CYRTUS, Meig. *Acrocera*, Fab. Antennæ nearly vertical, the first joint cylindric, second ovate with a terminal seta: proboscis exserted, horizontal, longer than the head. Meig. *Zw.* iii. pl. xxiv. fig. 1–6.

C. *gibbus.* Proboscis and palpi yellow: thorax nearly globose, arched, pubescent, yellow, with a black dorsal line anteriorly, which is widened in the middle into a large spot: scutellum semicircular, black, with a triangular spot of yellow at the hinder margin: abdomen very thick, inflated, globular, flat beneath, of a yellow colour, with four black cross bands produced in the middle into a point: wing-scales large and cinereous; the halteres small, and yellow: wings lanceolate, hyaline, yellowish at the anterior margin: legs ferruginous. Four to five lines. A rare insect, found occasionally in the south of Europe and in the north of Africa. The species in general frequent flowers.

GENUS ACROCERA, Meig. Antennæ vertical, the second joint spindle-shaped, with a terminal seta: proboscis concealed. Meig. *Zw.* iii. pl. xxiv. fig. 7–10.

A. *sanguinea.* Thorax black, naked, with a white spot on the shoulder, and a whitish line before the wing-scales: abdomen blood-red, with four dorsal spots, the three anterior ones triangular: legs black: wing-scale blackish brown: wings brownish, the marginal nervures dark. Three and a half lines. Meig. *Zw.* iii. pl. xxiv. fig. 10. The species are few in number, and frequent moist places. The one just described is found on the continent. Two others, *A. globulus* and *A. albipes*, inhabit England.

GENUS HENOPS, Illig. (Plate CCLI. figures 15 and 15 *a*.) Antennæ porrect, inserted into the upper margin of the mouth, the basal joint patelliform, second ovate, with a terminal style thickened at the apex: proboscis concealed.

H. *marginatus.* Thorax black, with fine grey pubescence: abdomen black brown or pitch colour, the hinder margin of the segments white: legs entirely rufous: wing-scales and wings hyaline, the last with yellowish-brown

marginal nervures: belly white, with dark-brown bands. Two to three lines. Meig. *Zw.* iii.; Curtis, *Brit. Ent.* pl. cx. This species has been frequently taken in the New Forest.

FAMILY XIII.—STRATIOMYDÆ.

Antennæ porrect, approaching at the base, three-jointed; third joint ringed: proboscis along with the head projecting: ocelli three: abdomen with five segments: onychii three.

Genus Pachygaster, Meig.; named from παχυς, *thick*, and γαστηρ, *the belly*. Antennæ with the third joint globose, four-ringed, and having a terminal seta: scutellum unarmed. Meig. *Zw.* iii. pl. xxiv. fig. 16–23.

P. *ater*. Antennæ of the males brownish, of the females rufous: forehead of the males triangular, small, shining white, with a longitudinal furrow; the crown with three ocelli; thorax rather elongate, black; scutellum unarmed: abdomen wider than the thorax, arched above, flat beneath, black, naked: legs pale yellow with black thighs: halteres with a yellowish stalk and a black-brown knob: wings lanceolate, microscopically pubescent, when in a state of repose lying parallel with the body; the basal half brown, the rest hyaline. Two lines. *Vappo ater*, Lat. Leach. Not a scarce insect on the continent, and in this country it has been found in Darent, Birch, and Coombe Woods, besides various other places. The larva is elongated, of a reddish grey, marked with three obscure longitudinal bands.[1] Another British species is represented in Curtis' *Brit. Ent.* fol. 42, and named after Dr Leach, by whom it was discovered in Devonshire. The most obvious mark of distinction is derived from the appearance of the wings, which are uniformly hyaline in *P. Leachii*, while the lower half is brown in *P. ater*.

Genus Sargus, Fab. (Plate CCLI. figures 16 and 16 *a*.) Antennæ with the first joint sub-cylindric, second cup-shaped, third lenticular, three-ringed, having an apical seta: scutellum without spines. Meig. iii. 104; Lat. *Gen. Crust.* iv. 278.

S. *Réaumuri*. Male. Head black; forehead with two white spots over the antennæ, the latter black brown; eyes green, without purple bands: thorax shining brassy green above, with a longitudinal line of white on each side: abdomen bright copper colour, with yellowish white pubescence: halteres and feet rufescent, the tarsi brown at the apex: wings reddish brown, the stigma somewhat obscure. Six lines. Meig. iii. 109; Réaumur, *Ins.* iv. 22, pl. 5–8.

The female is considerably less than the male, and is strikingly distinguished by having the abdomen of a bright steel blue, with the two basal segments red, having a narrow steel-blue line on the back. This sex is figured by Mr Curtis, *B. E.* pl. cccv. This beautiful species has been taken occasionally in England, and has been observed oftener than once near Edinburgh. On one occasion Mr Duncan found both sexes abundant in an open wood on the banks of the Teviot. All the species hitherto described occur in Britain, excepting two. Several, particularly *S. infuscatus*, *S. politus* (*Musca polita*, Linn.), and *S. formosus*, are common throughout the south of Scotland, the two former frequenting woods and gardens, the latter marshy meadows. *S. flavipes* (Meig. pl. xxvi. f. 14), which appears to be one of the rarer species, has been captured among the Pentland Hills.

The insects of this genus delight in warm and sunny weather. During cloudy days they may be found upon the leaves of various plants, dull, inactive, or in a state of stupor. One of the larvæ has been described by Réaumur. Its form was oblong-oval, narrowed to a point in front; the head scaly, furnished with a couple of hooks; the body thinly beset with hairs. It was found in cow-dung. It became a chrysalis without changing its skin, and the perfect insect made its exit by knocking off the anterior lid of its hardened envelope. Macquart divides the genus into two sections.

Genus Nemotelus, Fab. Antennæ inserted into the apex of a conical hypostoma, the lower joints equal, third elongate, spindle-shaped, four-ringed, the apex with a two-jointed style: scutellum without spines. Meig. *Zw.* iii. pl. xxv. f. 16–20.

N. *uliginosus*. Male. Forehead black, with a whitish spot over the antennæ: thorax shining black, with fine cinereous pubescence, and a white vitta extending from the shoulder to the base of the wing: scutellum black: abdomen white, black at the base, and having a spot of the same colour before the apex: legs white; thighs black, with a white apex; hinder tibiæ black, white at the base and apex: halteres white: wings hyaline, the marginal nervures yellowish.

Female. Shining black: head with short whitish silken hair, and an interrupted cross band of the same colour over the antennæ: thorax with short whitish silky pubescence, the shoulders and a line on each side running to the base of the wings, white: abdomen surrounded with yellowish white, and marked with three rows of triangular spots, the side rows united to the yellowish margin: in other respects like the male. Three lines. Meig. *Zw.* iii. 114, pl. xxv. fig. 19, *female*. *Musca uliginosa*, Linn.; Don. xv. 31, pl. 519.

Found in meadows and marshy places, in Britain and on the continent of Europe.

Genus Clitellaria, Meig. Antennæ with the two lowest joints nearly equal, the third conic, five-ringed, with a two-jointed terminal style. Meig. *Zw.* iii. pl. xxv. f. 21–25.

C. *Ephippium*. Hypostoma and forehead black, the latter in the female with two whitish pubescent spots: antennæ black brown: thorax covered with a silky pile of a fiery red colour, the sides and breast black; before the base of the wing there is a black pubescent spine: scutellum black, with two pubescent spines rising from the hinder edge: abdomen black: halteres yellow: wings smoke colour, deepening at the anterior edge: legs black, the hinder tibiæ somewhat crooked. Five lines. Meig. *Zw.* iii. pl. xxv. f. 25. Inhabits Germany, France, Switzerland, and England.

Genus Oxycera, Meig. Antennæ with the two lowest joints equal; third spindle-shaped, four-ringed, with a two-jointed terminal style: scutellum armed with two spines.

O. *pulchella*. Male. Hypostoma black, with whitish-grey pubescence: eyes with a purple fascia: forehead with two silver-white pubescent spots: antennæ black: thorax black: from the shoulder extends a yellow vitta to the base of the wings, where it turns downwards somewhat pointedly; behind the base of the wing towards the scutellum there is a yellow triangle: scutellum and spines yellow, the latter with a blackish apex: abdomen black, each side of the third and fourth segment with a long spot of a fine yellow colour directed forwards, and a triangular one on the terminal segment: belly black, the second, third, and fourth segments yellowish in the middle: legs yellow: thighs black in the middle: the anterior

[1] Macquart, *Dipt. du Nord de la France*, p. 112.

tarsi with the four last, and the others with the three last joints, blackish brown: halteres yellow: wings hyaline, the nervures brown.

Female. Hypostoma and forehead yellow, with a black vitta in the middle; crown black; hinder margin of the eyes yellow: on the first segment of the abdomen, beneath the scutellum, is a yellow spot: in other respects the same as the male. Three lines. Meig. *Zw.* pl. xxv. f. 29; *Musca hypoleon*, Don. v. 6, pl. cxlvi. f. 3. Found in summer on hedges and bushes near lakes and marshes.

Genus Stratiomys, Geoff. Antennæ with the second joint cup-shaped, third elongate, somewhat spindle-shaped, five-ringed: scutellum armed with two spines.

S. *Potamida.* Thorax fuscous; scutellum with a black band at the base, the spines entirely yellow: abdomen black, the second segment with a yellow triangular spot on both sides, and on the hinder margin of the third segment there is a narrow band of yellow, which is broad and interrupted in the males, but entire in the females; the following segments have a narrow band in both sexes, and the anal one is marked with a yellow triangle: the belly is dirty yellow marked with four bands of black, the first one interrupted. From six to seven lines. *Musca Chamælcon*, Harr. *Ex.* 44, pl. xi. fig. 1. Of occasional occurrence in Britain, and on the continent of Europe. *S. Chamæleon* is more frequently met with in this country, particularly in the more northern parts.

The manners of these insects have been studied by Geoffroy and Réaumur. The larvæ have a long flattened body, covered by a coriaceous or rather solid skin, divided into segments, of which the last three, more slender and elongated than the others, form a tail terminated by a radiated expansion of barbed or plumy hairs. The head is scaly, small, oblong, and provided with a great many appendages and hooks, with which they agitate the water in which they dwell. They respire by an opening in the caudal segment, while suspended from the surface. Their skin becomes the cocoon of the nymph. The latter scarcely change their form, but they assume a rigid consistence, and become incapable of motion. They float upon the water, and their tails frequently form a right angle with the body. The perfect insect issues from a cleft which opens in the second ring. The species are few in number. About half a dozen are found in Britain.

FAMILY XIV.—SYRPHICI.

Antennæ three-jointed; third joint compressed, not ringed, with an apical style, or a dorsal seta at the base: ocelli three: proboscis concealed: abdomen with five segments: onychii two.

a. Antennæ with a terminal style.

Genus Callicera, Meig. Antennæ inserted on a common tubercle, the first joint cylindrical, second of equal length, compressed and dilated at the apex, the third terminating in an acuminated style: abdomen conical: wings incumbent, parallel.

C. *ænea.* Hypostoma yellow and pubescent, having a black line down the middle: thorax pubescent, of a yellow colour, blackish on the back, and marked with three obscure lines: scutellum blackish, the pubescence yellowish white: abdomen shining brassy green, with yellow pubescence, of a conical form in the male, more rounded in the female, and in the former marked with a black nearly triangular spot at the base; legs yellow, the thighs almost entirely black. Males five and a half, females nearly seven lines. *Bibio ænea*, Fab.; *Musca ænea*, Gmelin.

This insect has occurred at Berlin and in the south of France.

Genus Ceria, Fab. Antennæ seated on a common footstalk; the basal joint cylindrical, second and third equal, clavate, compressed, and furnished with an apical style: abdomen cylindrical: wings divaricating?

C. *conopsoides.* Shining black and pubescent: peduncle of the antennæ elongate, and ferruginous; thorax with the shoulders and a small spot near the base of the wings yellow: abdomen with a yellow band on the hinder margin of the second, third, and fourth segments: legs rufous, the thighs brown. Five to six lines *Ceria clavicornis*, Fab.; *Musca conopsoides*, Linn.; Curtis, *B. E.* 186 ♀. Very rare in Britain, but not unfrequent on the continent. There is an English specimen in the British Museum, presented by Dr Leach.

b. Antennæ with a dorsal seta.

Genus Microdon, Illig. Antennæ porrect, the first joint elongate, cylindrical, the third with a naked dorsal seta at the base: scutellum armed with two teeth: wings incumbent, parallel.

M. *apiformis.* The head and thorax are dark brassy, and shining; the hypostoma is covered with bright yellow pubescence, but on the forehead, thorax, and scutellum it is of a fulvous colour: abdomen black, clothed with shining golden-yellow pile, which forms a narrow band at the hinder margin of the first segment, and a broader one on the second, somewhat interrupted in the middle, and covers nearly the whole of the third and fourth segments: wing-scales and halteres white; wings brownish: thighs black, with ferruginous pile, the tibiæ and tarsi entirely ferruginous. Four to five lines. *Musca apiformis*, Degeer, pl. vii. fig. 18–20; *Musca mutabilis*, Linn.; Curtis, *B. E.* 70.

Meigen describes four European species, but the above is the only one known as British. It has been found in the New Forest, and near Lyndhurst, in Hants, but appears to be scarce in the country, although common in France and many other parts of Europe.

Genus Chrysotoxum, Meig. Antennæ inserted on a frontal tubercle, porrect; first joint cylindric, the rest somewhat compressed, equal, the terminal one with a naked dorsal seta at the base: scutellum unarmed: abdomen margined: wings divaricating.

C. *arcuatum.* Hypostoma shining yellow, with a black line down the middle; the forehead of the females black, with two yellow spots; antennæ black: thorax black, with an interrupted yellow line on each side, and two abbreviated cinereous lines on the back: abdomen without hairs, black, and having four arched interrupted bands of golden yellow; belly with four golden-yellow spots; the wings are yellow at the anterior margin, and behind the middle, near the anterior edge, there is a small brown spot. Five and a half lines. *Syrphus arcuatus*, Fab.; *Musca arcuata*, Linn. This insect occurs not unfrequently throughout the south of Scotland and England during the autumn, frequenting various flowers. We have often taken *C. bicinctum* in company with it, on the flowers of *Senecio Jacobæa*, in Roxburghshire. The species have a *waspish* look, from their prevailing hues of black and yellow. They feed on the juices of flowers. Their flight is rapid.

Genus Psarus, Fab. Antennæ inserted on a common peduncle, porrect, the radical joint cylindrical, second elongate and compressed, third oblong and compressed, with a naked seta placed on the middle of the back: wings incumbent, parallel.

P. *abdominalis.* Hypostoma black, with a grey play of colour on the sides; forehead black, with two white spots: thorax black and naked: scutellum semicircular and unarmed: abdomen naked, nearly linear, reddish brown; the base and apex black, sometimes having a black line along the back: wing-scales and halteres white: thighs

black; tibiæ and tarsi inclining to brown. Four lines. *Syrphus abdominalis*, Fab.; *Psarus abdominalis*, Lat. Appears to be a rare and little-known species. Specimens found in this country are preserved in the British Museum.

GENUS PARAGUS, Lat. Antennæ with the two basal joints equal, the third elongate, compressed, with a naked dorsal seta before the middle: hypostoma somewhat convex, smooth: abdomen linear, transversely rugose; the hinder metatarsus somewhat thickened: wings parallel, incumbent.

P. *obscurus*. Female. Antennæ proportionally shorter than in most of the other species, and entirely dark brown: eyes pubescent: thorax with a slight grey play of colour, the sides covered with pubescence of a silvery hue: abdomen shining black: legs yellow; the thighs black, with the apex yellow: halteres white. Two and a half lines. Inhabits France and England.

GENUS ASCIA, Meg. Antennæ with the third joint oblong, compressed, having a naked dorsal seta before the middle: hypostoma impressed, smooth, produced beneath: abdomen contracted at the base: hinder thighs thickened, and spinose beneath: wings incumbent, parallel.

A. *floralis*. Abdomen black, and marked with two yellow fasciæ, which are entire in the male, and interrupted in the female: anterior legs yellow, the tibiæ with a black ring before the apex; the hinder legs black, with a metallic lustre, the thighs yellow at the base, the tibiæ yellow, with a black band in the middle, and the tarsi black: wings hyaline. Two and a half lines.

Found occasionally in gardens and fields in the southern counties of Scotland, and in England.

GENUS SPHEGINA, Meig. Antennæ with the terminal joint orbiculate, compressed, with a naked dorsal seta at the base: hypostoma impressed, smooth: abdomen contracted at the base: hinder thighs clavate, spinose beneath: wings parallel, incumbent. Meig. iii. 193.

S. *nigra*. Hypostoma whitish; antennæ rufous-brown: thorax and abdomen shining black, the former with a greenish tint: halteres yellowish white: the four anterior legs pale yellow; thighs of the hinder pair black, yellow at the base; the tibiæ with two brown bands; tarsi black. Three to three and a half lines. Two species only belong to this genus, both of which are to be found in Britain. Mr Duncan took a few examples of the above in the neighbourhood of Edinburgh in the summer of 1830. The other species, *S. clunipes* (Meig. pl. xxviii. f. 5) is of more frequent occurrence.

GENUS BACCHA, Fab. Antennæ with the third joint sub-orbicular, compressed, having a naked dorsal seta at the base: hypostoma tuberculated: abdomen elongate, attenuated before, and clavate behind: legs simple: wings parallel and incumbent.

B. *nigripennis*. Antennæ brown: thorax dark brassy, the abdomen inclining to golden green, and flat behind; at the base of the third segment there is a scarcely perceptible yellow spot on each side, and a yellow band on the fourth: anterior legs yellow; the hinder ones brownish, with the base of the thighs yellow: wings blackish. Three lines. Found in Austria by M. Megerle. It likewise occurs in Britain, along with six other species—nearly the whole that the genus contains.

GENUS EUMERUS, Meig. Antennæ with the third joint orbicular, compressed, and having a naked dorsal seta before the middle: hypostoma sub-convex, villose, smooth: hinder thighs thickened, and spinose beneath: wings incumbent, parallel.

E. *grandis*. Hypostoma covered with whitish pubescence; forehead of the males similar, that of the female black, with white pubescence under the eyes: antennæ dark brown: thorax dark brassy, with two whitish lines anteriorly, the sides somewhat shining: abdomen black, the sides testaceous, and adorned with three pair of crescent-shaped spots: legs dark metallic green, the tibiæ and tarsi with ferruginous pubescence: halteres brown: wing-scales white; wings grey. Five lines. Meig. *Zw.* iii. pl. xxviii. f. 18. Five species of Eumeri are found in this country: *E. ruficornis, ornatus, strigatus, funeralis,* and *silene*. The one described above occurs on the continent.

GENUS XYLOTA, Meig. Antennæ inserted on a frontal tubercle, nutant, the third joint sub-orbicular, compressed, with a naked dorsal seta at the base: hypostoma impressed, blunt below, smooth, or somewhat tuberculated: hinder thighs thickened, and spinose beneath: wings incumbent, parallel.

X. *sylvarum*. Hypostoma yellowish white, and finely pubescent, the forehead similar in the male, but in the female shining black, with two white spots anteriorly: antennæ brown: thorax dark metallic green, with a grey spot on each shoulder; the pubescence on the sides golden yellow: scutellum dark green: abdomen black, the two first segments thinly clothed with golden pubescence; similar pubescence covers the base and sides of the third, leaving a triangular black spot behind, and the fourth segment is entirely covered with it; fifth segment minute and shining black: wing-scales and halteres yellowish white: wings brownish, with a ferruginous stigma: legs ferruginous, the thighs and two last tarsal joints black; hinder thighs club-shaped, and armed with small prickles; tibiæ crooked, and having a brown play of colour behind. Six lines. *Musca sylvarum*, Linn.; *Syrphus sylvarum*, Fab.; *Milesia sylvarum*, Lat. Found occasionally in various parts of the continent. We have taken single specimens near Edinburgh, and in the neighbourhood of Jedburgh. *X. segnis*, and *pipiens*, are comparatively common in England and the south of Scotland. The former is often plentiful at Roslyn. The larva of this genus, described by Degeer, was found in the dung of horses.

GENUS MILESIA, Fab. Antennæ inserted on a frontal tubercle, the third joint lenticular, with a naked dorsal seta at the base; hypostoma impressed, smooth, or slightly tuberculated; legs simple, the hinder tibiæ compressed; wings incumbent, parallel, the intermediate transverse nerve oblique.

M. *speciosa*. Hypostoma and forehead ferruginous, with a yellowish-white play of colour on the sides; the crown black: antennæ ferruginous: thorax dark brassy green, finely pubescent, blackish on the sides, and yellow on the shoulders: abdomen dark brassy, cylindrical, and finely pubescent; having a line along the back, and the hinder margin of the segments covered with shining golden-yellow pubescence, and before this yellow edging there is a transverse band of black: wing-scales white: halteres bright yellow: wings brownish yellow along the anterior margin, but before the apex this colour passes into brown: thighs dark brown, with a ferruginous spot at the apex; tibiæ and tarsi ferruginous. Seven lines. Found, according to Meigen, near Paris, and likewise in Austria and Italy. "It is now several years," says Mr Curtis, who has given a beautiful representation of this insect in his *Brit. Entom.* fol. 34, "since this fine and rare insect was discovered in the New Forest by Mr D. Bydder, and the beginning of June of the present year (1824) I took four near Brockenhurst: they appear to delight in settling in the thickest parts of the Forest, where a partial shadow is thrown by the surrounding foliage upon the trunks of trees, or the flat surface remaining when they have been felled."

GENUS PIPIZA, Meig. Antennæ nutant, the third

joint ovate and compressed, having a naked dorsal seta at the base: hypostoma smooth: hinder thighs somewhat thickened: abdomen oblong-elliptical: wings parallel, incumbent.

P. *Artemis.* Black, with whitish hair: the second segment of the abdomen with a lunate fascia of a red colour: thighs black, tibiæ ferruginous anteriorly, brown behind; tarsi ferruginous: halteres bright yellow: wing-scales white; outer half of the wings brown, the colour becoming paler at the apex: belly black, yellow anteriorly. Three lines. Inhabits Austria and England. There are fifteen British species of this genus, and twenty-nine are indigenous to Europe.

Genus Psilota, Meig. Antennæ nutant, the terminal joint oblong-ovate, with a naked dorsal seta at the base: hypostoma impressed, truncated beneath: eyes hirsute: wings incumbent, parallel.

P. *anthracina.* Hypostoma and forehead bluish black; the body of a similar colour, and covered with very short pubescence; abdomen oval: legs black, the thighs all straight; the tarsi with fine ferruginous pubescence; the hinder legs somewhat elongate, and the tibiæ a little bent: wing-scales and halteres white; wings hyaline, somewhat yellowish at the base, and the stigma bright yellow. Three lines. Meig. *Zw.* iii. pl. xxix. f. 20. Found in Germany and Britain.

Genus Rhingia, Fab. Antennæ porrect, nutant, the third joint lenticular, the base with a naked dorsal seta: hypostoma somewhat impressed, elongate beneath, conical: wings incumbent, parallel. Meig. iii. 257; Lat. *Gen. Crust.* iv. 320.

R. *rostrata.* Hypostoma and rostrum ferruginous, shining, the latter brown at the tip; antennæ ferruginous; forehead of the females grey, with a dark streak: thorax grey, with three black-brown lines; scutellum shining, brownish yellow: abdomen ferruginous, the basal segment sometimes blackish, and a longitudinal brown line on the second: legs ferruginous, the hinder tarsi brownish: wing-scale and halteres light yellow: wings somewhat greyish, yellowish at the anterior margin. Four lines. Meig. iii. 258. *Conops rostrata*, Linn., &c. Common throughout the country. *R. campestris* (Curtis, *B. E.* pl. clxxxii.), which differs from the above chiefly in having the incisures of the abdomen, and a longitudinal dorsal line, of a black colour, is likewise of frequent occurrence, and is probably not specifically distinct. The name of a third species, *R. monostigma*, has been recently published, but we are unacquainted with its characters and history. We have but a slight knowledge of the metamorphoses of these insects. Indeed all that is yet known is inferred from the fact of Réaumur having found *Rhingia rostrata* in the perfect state in a sand-box (*poudrier*) in which he had previously enclosed some cow-dung containing unknown larvæ. The perfect insects occur in gardens and meadows. The species are by no means numerous.

Genus Brachyopa, Hoff. Antennæ inserted on a frontal tubercle, nutant, the terminal joint lenticular, and having a hirsute dorsal seta at the base: hypostoma impressed and elongate beneath, truncated: wings incumbent, parallel, one half longer than the abdomen.

B. *bicolor.* Hypostoma, antennæ, and forehead (of the males) ferruginous, with a white play of colour; forehead of the females grey, with a yellow spot anteriorly: thorax dark grey or lead colour, with three brown lines, of which the central one is double: scutellum rust-brown: abdomen ferruginous, with a black dorsal line on the second segment, which however is sometimes wanting: legs ferruginous, with dark-brown tarsi: wing-scales white: halteres bright yellow: wings unspotted, slightly obscured with brown. Three lines. *Rhingia bicolor*, Fallen. The insects of this genus are found on flowers, but seem to be in general rare. The above, and another species named *B. conica*, are said to have occurred in England.

Genus Chrysogaster, Meig. Antennæ nutant, the third joint compressed, orbiculate, or oblong, having a naked dorsal seta at the base: forehead of the female crenated on both sides: abdomen depressed: wings parallel, incumbent.

C. *ænea.* Shining brassy, except the apex of the abdomen, which is dull black; the belly dark green: antennæ testaceous: wings hyaline, partly of a yellowish-brown colour, with a ferruginous stigma. Three lines. Inhabits Austria and Britain, but seems everywhere rare.

Genus Syrphus, Fab. (Plate CCLI. figures 17 and 17 *a.*) Antennæ porrect, nutant, three-jointed; the third joint orbicular or oval, compressed, with a pubescent dorsal seta at the base: hypostoma tuberculated, feet simple, slender: wings incumbent, parallel, the ordinary transverse nerve nearly perpendicular.

S. *Lucorum.* Hypostoma white, with a shining black line down the middle; forehead whitish, having a black spot over the antennæ, and a brown line in the females: antennæ black, with a very finely pubescent seta: thorax black, with reddish-yellow pile; scutellum rufous: abdomen having the first segment whitish, with pubescence of the same colour, the male with a wide dark-coloured vitta; third segment deep black; fourth black, with whitish pubescence and somewhat glossy, especially on the sides: legs dark brown, the base of the tibiæ whitish: halteres and wing-scales brown; wings hyaline, having a dark-brown vitta in the middle of the anterior margin extending half way across. Five lines. Meig. iii. 313, pl. xxx. f. 27. *Musca lucorum*, Linn. Not unfrequent on umbelliferous plants in woods throughout the country. The genus *Syrphus*, as characterized by Meigen, comprehends nearly 100 species, of which upwards of one half, besides a considerable number of others recently discovered, are to be found in Britain. The dissimilarity in form and structure which prevails among many of these insects, has led to their distribution, by later writers, into three generic groups, distinguished by the names *Cheilosia, Scæva, Syrphus;* and they appear to be susceptible of still further subdivision. As the English species are comparatively well known, it may be interesting to mention such as we have ascertained to inhabit Scotland: *S. ostraceus* (frequent), *variabilis, lunulatus, Pyrastri, seleniticus, Ribesii* (common), *balteatus* (common), *cinctus, decorus, umbellatarum, tæniatus, melliturgus, Rosarum, Ocymi, granditarsus* (three last near Edinburgh, not common). The larvæ of the Syrphi prey upon Aphides. Their form is that of an elongated cone. Their segments are very retractile.

Genus Pelecocera, Hoff. Antennæ porrect, the third joint somewhat patelliform, the apex furnished with a thick, short, three-jointed seta: hypostoma arched beneath.

P. *tricincta.* Hypostoma white, with a shining black vitta: thorax black, shining, the shoulders white, and the sides before the base of the wings marked with a white streak: scutellum shining black; abdomen likewise black, with a broad ferruginous band at the base of the second, third, and fourth segments: legs reddish yellow, the hinder pair with a brown ring on the thighs and tibiæ: wing-scales and halteres white: wings somewhat brownish, with a ferruginous stigma. Three lines. Found in some parts of the continent, but everywhere rare.

Genus Sericomyia, Lat. Antennæ porrect, nutant, the third joint patelliform; the base with a plumose dorsal seta: hypostoma descending, tuberculated: wings parallel, incumbent, hirsute.

S. *borealis.* Hypostoma ochreous, with a black line; antennæ dark brown; forehead of the males yellow, of the females black brown: thorax black, with a tuft of whitish pubescence on each shoulder, and golden-yellow pubescence on each side before the base of the wing: scutellum blackish brown: abdomen black, with four ochreous bands, the first, and sometimes the second also, somewhat interrupted; belly dull ochreous, brown at the base: legs rufous, base of the thighs black: wing-scales yellow: halteres brown: wings hyaline, with the anterior margin yellowish, and sometimes with a pale-brown tinge before the apex. Seven lines. *Syrphus borealis*, Fallen; *Musca lappona*, Degeer. Abundant in some parts of the south of Scotland during the autumnal months, and frequently seen on the flowers of *Senecio Jacobæa*, in company with numerous species of the genus *Eristalis.* Its appropriate locality seems to be elevated pasture lands, and the sides and summits of hills. In the latter situation we have occasionally heard it, in fine weather, emit a peculiarly shrill and stridulent note, which is sufficiently loud to be heard at a considerable distance. A nearly allied species, *S. lappona*, Linn., occurs among the Pentland Hills, near Edinburgh.

GENUS TROPIDIA, Meig. Antennæ nutant, third joint patelliform, with a naked dorsal seta: hypostoma carinated, smooth: hinder thighs thickened, with a single tooth at the apex beneath: wings parallel, incumbent, hirsute.

T. *fasciata.* Hypostoma greyish white, with a black longitudinal line, and covered with fine silky hairs; antennæ rufous: thorax with yellow pubescence, of a dark green, somewhat metallic, with two whitish abbreviated lines on the back, and a spot on each shoulder: abdomen with ferruginous pubescence, of a dark brown, and having a rufous interrupted band on the second, third, and fourth segments: thighs of the anterior legs blackish, the apex rufescent, the tibiæ and tarsi rufous, with a brown apex: hinder thighs blackish, the tibiæ crooked, reddish at the base, the other parts, as well as the tarsi, brown: halteres and wing-scales white: wings hyaline. Four lines. Found in some parts of the continent on *Achillæa ptarmica*, in the neighbourhood of Paris, and in Austria. The only other species described by Meigen, *T. milesiformis*, has been found in Britain, along with another, named *T. rufomaculata* (Curtis), which does not appear to be known to continental naturalists.

GENUS MERODON, Fab. Antennæ nutant, the terminal joint oblong or elliptical, compressed, with a naked dorsal seta at the base; hypostoma smooth and villose: hinder thighs thickened, with a single tooth at the apex beneath: wings incumbent, parallel, hirsute.

M. *equestris.* Male. Hypostoma and forehead with greyish white pubescence; antennæ black: thorax anteriorly dark brassy, with ferruginous pile, shining black behind, with pile of the same colour: scutellum and abdomen coloured and clothed like the anterior part of the thorax: legs black, the anterior tibiæ and tarsi with ferruginous silky hairs; the hinder tibiæ with a tubercle on the inner side behind the middle, and a hooked spine at the end: halteres brown: wings nearly hyaline. Six lines. *Syrphus equestris*, Fab. Réaumur, *Ins.* iv. tab. xxxiv. fig. 9, 10. This species has occurred in Italy and near Paris. *M. clavipes* is the only British species known. It is figured and described in Curtis' *B. E.* fol. xcviii.

GENUS HELOPHILUS, Meig. Antennæ porrect, nutant, the terminal joint patelliform, the base with a naked dorsal seta: hypostoma descending, gibbous beneath: eyes naked: hinder thighs thickened, unarmed: wings divaricating, hirsute.

H. *pendulus.* Hypostoma yellowish white, with a shining black vitta in both sexes; forehead whitish yellow, the crown dark brown, and a small black spot over the antennæ; the latter dark brown, with a yellow seta: thorax straw colour, with three black vittæ: scutellum shining brownish yellow: abdomen deep black, with three unequal interrupted yellow bands: the belly pale anteriorly, the three last segments black, with white incisures: wing-scales and halteres yellow; anterior legs rufous, nearly the whole of the thighs and the tarsi brown; hinder legs dark brown, the apex of the thigh and base of the tibiæ more or less yellow. Five lines. *Syrphus pendulus*, Fab.; *Musca pendula*, Linn.; *Elophilus pendulus*, Lat Everywhere common. The species of this genus do not greatly differ from those of *Eristalis.* They are generally less hairy. Several exhibit the aspect of garden bees, as well as of other Hymenoptera. The larvæ, known under the name of rat-tailed worms (*vers à queue de rats*, Réaumur),[1] are remarkable for the great length and singular uses of their caudal extremity. It serves as a respiratory organ. The insect lies at the bottom of stagnant waters, generally concealed in the mud; but the point of its attenuated tail is meanwhile in contact with the surface. Réaumur found, by increasing the depth of water, that the larva could extend its respiratory tube to the height of five inches. After that, however, it was seen to leave the mud, and ascend the side of the vessel in which it was contained, that it might attain to the surface with greater ease. The tail seems composed of two parts, one of which slips into the other like the portions of a telescope. They are composed of annular fibres, and when these are contracted, each tube is greatly increased in length

GENUS MALLOTA, Meig. Antennæ nutant, third joint nearly four-angled, compressed, with a naked dorsal seta in the middle: hypostoma descending, gibbous: wings divaricating, hirsute.

M. *megilliformis.* Male. Hypostoma black, thickly covered with silken hairs of a pearl-grey colour, and having a naked shining black vitta; forehead black, pearly on the sides beneath; the hinder part of the head with ferruginous pile; antennæ black, the third joint with a white seta: thorax and abdomen dark green, thickly clothed with ferruginous hair; belly and legs black; wing-scales ferruginous; halteres also ferruginous, with the knob brown: wings nearly hyaline, with brown nervures. Six lines. Rare: The females have not been described. The genus contains only three species, none of which appear to be British.

GENUS ERISTALIS, Fab. Antennæ porrect, nutant, three-jointed; the third joint patelliform, with a plumose or naked seta at the base: hypostoma elongate, tuberculated: legs simple: wings spreading, naked (in the greater number of species).

E. *intricarius.* Male. Hypostoma and forehead black, with yellowish-white hair; antennæ black at the base, the third joint rufous, with a plumose seta of the same colour at the base: thorax black, thickly clothed with reddish-yellow hair; scutellum yellow: abdomen black, with ferruginous lateral spots, and clothed anteriorly with ferruginous hair, which on the hinder parts passes into a whitish-yellow colour: wing-scales blackish: wings hyaline, the central cross nerve more or less distinctly margined with brown: legs black, the apex of the thighs and basal half of the tibiæ white. Six lines. Meig. iii. 391. *Syrphus intricarius*, Fab.; *Musca intricaria.* Linn. Of frequent occurrence during summer on flowers and

[1] *Mémoires*, t. iv. p. 442.

Diptera Proboscideæ.

plants. Several species of this extensive genus are very common in this country, particularly *E. tenax, similis, horticola*, &c. About a score inhabit Britain. The larva of *E. narcissi* (which inhabits the bulb of the plant from which it derives its name) is figured and described by Réaumur.[1]

GENUS VOLUCELLA, Geoff. Antennæ decumbent, the third joint elongate, compressed, with a long plumose dorsal seta at the base: hypostoma impressed above, elongate beneath, conical, gibbous: wings divaricating. Meig. iii. 401; Lat. *Gen. Crust.* iv. 322.

V. *pellucens.* Hypostoma, forehead, and antennæ shining ferruginous, the latter with a black plume: thorax shining black, bristly: scutellum testaceous brown, sometimes black,[2] bristly: abdomen pubescent, shining black, the second segment yellowish white, pellucid, having a central line of black in the males, but usually uninterrupted in the females, except by a very faint black line; belly like the back, except the anterior part of the third segment, which is likewise transparent: legs black: wing-scales yellowish: halteres with a blackish stalk, the knob white: wings yellowish at the base, with ochreous veins, the rest greyish, with brown veins. Seven lines. Meig. iii. 405. *Musca pellucens*, Linn. An insect of not unfrequent occurrence in Britain during the summer months, frequenting flowers in sheltered situations exposed to the sun. In the summer of 1829 it appeared in unusual abundance in the fields adjoining Duddingston wood, near Edinburgh. All the other species belonging to the genus (as now restricted) are to be found in Britain, with the exception of *V. zonaria* (Meig. iii. pl. xxxii. f. 27). The most common in Scotland next to the species described is *V. plumata*, which is found occasionally throughout the southern counties. *V. bombylans* appears to be considerably scarcer; the only examples which we have met with were from Dumfriesshire and East Lothian. The larvæ of these insects inhabit the nests of wasps and bees, and live at the expense of the proper owners. Réaumur has detailed their history at great length, and in a very interesting manner. " Lepelletier de Saint Fargeau a eu occasion d'observer que les volucelles de diverses espèces s'accouplent trés-bien ensemble; il a lu un Mémoire à ce sujet à l'Académie des Sciences."[3]

FAMILY XV.—PLATYPEZINÆ.

Antennæ porrect, two or three-jointed, with a naked apical seta: proboscis concealed; thorax without a transverse suture: abdomen with six segments: wings incumbent: the small cross nerve of the middle bent towards the base: halteres naked.

GENUS CYRTOMA, Meig. Antennæ approximating, two-jointed, first joint small, cylindric; second elongate, conic, compressed, the apex with a two-jointed style: proboscis subporrect: hinder legs elongate: wings incumbent, parallel. Meig. iv. 1.

C. *nigra.* Black; halteres yellow; the legs brown; the hinder tibiæ club-shaped, the lowest joint of the tarsi thickened; wings somewhat brownish. Two lines. Found in Germany and elsewhere occasionally. This genus contains three species, none of which are known to inhabit Britain.

GENUS PLATYPEZA, Meig.; name derived from πλατυς, *broad*, and πεζα, *the foot.* Antennæ straight, approximating, three-jointed, the lower joints sub-cylindric, third ovate, compressed, the apex with a three-jointed naked seta: proboscis concealed: hinder feet thickest, tarsi dilated, the joints nearly equal: wings incumbent, parallel.

P. *boletina.* Male. Velvet black; abdomen with greyish-black bands: legs brown: halteres black brown: wings hyaline.

Female. Clear ash-grey, abdomen with a narrow deep black cross band, somewhat widened in the middle, before the incisures; the first segment without a band: halteres and legs bright yellow: wings hyaline. One and a half line. Fallen. Occurs in Germany and England, rare.

GENUS CALLOMYIA, Meig. (Plate CCLI. figures 18 and 18 *a.*) Generic name from καλος, *beautiful*, and μυια, *a fly*. Antennæ straight, three-jointed; the lower joints sub-cylindric, third compressed, acute; the terminal seta elongate, three-jointed: proboscis concealed: hinder legs elongate, thick, the metatarsus elongate: wings incumbent, parallel.

C. *amœna.* Male. Body velvet black: halteres rufous: fore legs honey-yellow, the thighs blackish brown: hinder legs entirely black brown: wings hyaline.

Female. Hypostoma and forehead bright blue: thorax bright blue on the sides, with a silvery lustre: this colour extends forwards along the thorax in the form of a bow, and before the scutellum there is likewise a silvery band: scutellum black: abdomen with the three first segments orange yellow, the fourth and sixth deep black, the fifth silvery blue, with a black line on the middle; fore legs rufous; hinder legs black, with rufescent thighs: halteres rufous: wings hyaline. Two lines. Meig. *Zw.* iv. pl. i. f. 13. This species has been recently taken in England.

FAMILY XVI.—MEGACEPHALI.

Antennæ three-jointed; the third joint deflexed, with an erect seta at the base: hypostoma linear, narrow: proboscis concealed: abdomen consisting of six segments: wings incumbent; the short transverse nervure in the middle: halteres naked.

GENUS PIPUNCULUS, Lat. (Plate CCLI. figures 19 and 19 *a.*) Antennæ triarticulate; first joint minute, second cup-shaped, third deflexed, acute, compressed, with an erect naked seta at the base: hypostoma narrow, linear: proboscis concealed: wings incumbent, parallel. Meig. *Zw.* iv. 18, pl. xxxiii. f. 15–24.

P. *spurius.* Deep velvet black, the apex of the abdomen somewhat shining: hypostoma silver white, changing, with a play of colour, into black: forehead very narrow, black, silver white above the antennæ: the latter, together with the legs, black: wings brownish, with a dark-coloured stigma. One line. Meig. *Zw.* iv. pl. xxxiii. f. 24. Occurs in England, but is rare.

FAMILY XVII.—DOLICHOPODES.

Antennæ porrect, three jointed: the third joint flat, with an apical or dorsal seta: hypostoma linear: proboscis somewhat exserted, with compressed incumbent palpi: thorax without a transverse suture: abdomen consisting of six segments: wings incumbent; the short transverse nerve bent towards the base: halteres naked.

GENUS RHAPHIUM, Meig. Antennæ approximating, the

[1] *Mémoire*, t. iv. p. 499, and pl. xxxiv.

[2] The scutellum is usually ferruginous when the insect issues from the chrysalis, but becomes darker as it advances to maturity, till it ultimately acquire the colour of the thorax.

[3] *Diction. Class. d'Hist. Nat.* t. xvi. p. 631.

third elongate, compressed, with a two-jointed style at the apex: eyes separated: wings incumbent, parallel.

R. *vitripenne.* Hypostoma bluish white; forehead shining steel blue: antennæ black, slender, those of the male as long as the abdomen, those of the female much shorter; the body dark metallic green, legs black, the anterior tibiæ brown; halteres white: wings hyaline. Three lines. Meig. *Zw.* iv. pl. xxxiii. f. 4. Four species of this genus, nearly half the number known, have been found in Britain. The species described occurs on the continent.

Genus Diaphorus, Meig. Antennæ with the third joint patelliform, having a villose dorsal seta: eyes meeting on the forehead; abdomen of the male with two filiform appendages on the under side of the apex: wings incumbent, parallel. Meig. *Zw.* iv. pl. xxxiv. f. 6–9.

D. *flavocinctus.* Hypostoma white; antennæ black: body black, with greenish reflections; the second segment of the abdomen, and sometimes the base of the third, ferruginous, transparent: anterior legs rufous, with blackish thighs, rufescent at the apex on the under side: middle pair of legs rufous, the basal half of the thighs black: hinder legs black, the upper half of the tibiæ rufous: halteres white: wings reddish brown. One and a half line. Meig. *Zw.* iv. pl. xxxiv. f. 8. Inhabits England, but is not common.

Genus Psilopus, Meg. Antennæ with the third joint patelliform, villose; furnished with an inclined villose dorsal seta before the apex: eyes separated: wings incumbent, parallel, the transverse nerve at the apex curved.

P. *platypterus.* Male. Head white: antennæ pale yellow; the third joint brown: palpi white: thorax cinereous-green, with a faint metallic lustre: abdomen brassy, the apical segment blackish: legs long, pale yellow: halteres yellow: wings very broad, hyaline.

Female. Hypostoma somewhat wider than in the male: legs pale yellow, with brownish tarsi. Two and a half lines; the females rather less. This and seven other species of Psilopi are found in Britain, but none of them appear to be frequent.

Genus Chrysotus, Meig.; named from χρυσοτος, *gold colour,* bright golden green being the prevailing colour of the species.—Antennæ with the terminal joint patelliform, villose, having an inclined villose seta at the apex: eyes separated: abdomen of the male with two filiform appendages at the apex beneath: wings incumbent, somewhat spreading. Meig. iv. 40, pl. xxxv. f. 7–11.

C. *neglectus.* Hypostoma of the males minute, blackish; that of the female wider and of a whitish colour; eyes of a beautiful golden green, with light-blue reflections: forehead metallic green: body bright golden green; legs straw yellow, with dark-brown tarsi, which are yellowish at the base: halteres white: wings hyaline, with a play of colour: the terminal segment of the abdomen small, lying in a cavity of the belly, with two short threads at its extremity. Meig. *Zw.* pl. xxxv. f. 10. Found in Britain, with seven other species, all that are known to belong to the genus.

Genus Porphyrops, Meig. (Plate CCLI. figures 20 and 20 *a.*) Generic name compounded of πορφυρα, *purple,* and οψ, *the eye.* Antennæ with the terminal joint oblong, acute, the seta villose and bent downwards: eyes separated: abdomen of the male with two filiform appendages at the apex beneath: wings incumbent, parallel. Meig. *Zw.* iv. pl. xxxv. f. 1–6.

P. *diaphanus.* Male. Hypostoma narrow and black; antennæ black; forehead black above, shining white beneath: thorax metallic black with green reflections, and having a long mark of changeable white on the sides anteriorly: abdomen conical, bluish, with a silvery lustre, viewed in another direction dark slate grey; with two interrupted reddish-yellow diaphanous bands on the second and third segments: legs dark brown, with ferruginous tibiæ which are brown behind: halteres white: wings vitreous. Three lines. *Musca diaphana,* Fab. Gmel.

The female has the thorax bright golden green with light-blue reflections; the abdomen more silvery than the male; and besides the two fasciæ, there is a yellowish spot on each side of the fourth segment: the anterior thighs are yellow at the apex. Inhabits England, and is not unfrequent in woods in the south of Scotland. Twenty-nine species have been described, ten of which are ascertained to inhabit Britain. All of them are minute insects, several being only a line in length, and none exceeding the size of the species described above. They are remarkable for beauty of colouring, which generally consists of changeable tints of metallic green, blue, and silver white. This circumstance, together with the activity of their motions, by which their colours are continually presented under varying lights, renders them more observable objects, in the shade and among the foliage of woods, where they usually prevail, than might be inferred from the smallness of their size.

Genus Medeterus, Fischer. Antennæ with the terminal joint short, sub-ovate, compressed, with a two-jointed dorsal seta: eyes separated: abdomen of the male with two filets at the apex: legs elongate, slender: wings incumbent, parallel. Meig. *Zw.* iv. pl. xxxv. f. 12–17.

M. *regius.* Male. Hypostoma and palpi white: antennæ black: forehead cinereous, with a greenish lustre: thorax dark green, with a greyish patch over the middle, in which are two blackish approximating longitudinal lines: sides of the thorax cinereous: abdomen sea-green, the hinder margin of the segments with a blackish band, bordered anteriorly with grass green: legs dark green: halteres white: wings hyaline, with a brown spot behind the middle, and the anterior margin from the middle to the apex more or less dusky, the apex itself with a white spot encircled with brown.

Female. Hypostoma black, steel-blue beneath; palpi greyish black margined with white: wings hyaline, with only the brown spot, the other markings wanting. Three lines. Found in France, Holland, Austria, and England.

Genus Sybistroma, Meg. Antennæ with the terminal joint oblong, compressed, having an elongate two-jointed seta on the back, the first joint longest; eyes separated: abdomen of the male incurved at the apex, and furnished with two flat ciliated processes. Meig. *Zw.* iv. pl. xxxiv. f. 18–20.

S. *patellipes.* Male. Hypostoma rather wide, white; forehead whitish with a metallic lustre: antennæ with the two basal joints black, the third ferruginous: body obscure brassy: legs yellow, the anterior tarsi of the male orbicular, and of a black colour: halteres white; wings brown. Two and a half lines. Communicated to Meigen by Dr Leach, who found the insect in England.

Genus Dolichopus, Lat. Antennæ with the third joint trigonate, compressed; the dorsal seta pubescent: eyes separated: abdomen of the male with the apex incurved, and furnished with two membranous ciliated lamellæ: wings incumbent, parallel.

D. *ungulatus.* Hypostoma silver white, rather wide in the female, and having a protuberance on each side beneath: palpi blackish: antennæ black: forehead, thorax, and abdomen brassy green: sides of the thorax slate-grey: coxæ greyish black, the anterior pair rufous beneath: abdomen bluish grey with a play of colour, the incisures and a line on the back black: legs rufous: apex of the hinder tibiæ, and all the tarsi, black: wings slightly cinereous: halteres yellowish white: anal segment of the abdomen in the males black, with bright yellow lamellæ

which are edged with black. Three lines in length. Lat. *Musca angulata*, Linn.; *Nemotelus æneus*, Degeer, *Ins.* vi. 78, 15, pl. xi. f. 14–22. Found in England, the south of Scotland, and various parts of the continent. The genus contains upwards of fifty species, none of them much exceeding three lines in length; nearly the half inhabit Britain. The larva of the one above mentioned is described by Degeer. He found it under ground in the month of May. It is white, cylindrical, eight lines in length, with a pointed or conical anterior. The head varies in form, being often sunk into the first segment. On the fourth of June it became a nymph, of a much shorter and thicker shape than the larva. It was then very restless, rolling about incessantly, with a constant movement of the abdomen. The perfect insect appeared on the 27th of the same month.

Genus Orthochile, Lat. Antennæ porrect, the third or terminal joint compressed, sub-orbiculate, and having a dorsal seta: proboscis exserted, perpendicular, with acute incumbent palpi: wings incumbent, parallel.

O. *nigrocærulea*. Thorax shining blue black, the sides of the breast slate-grey: abdomen dark metallic green; the anal segment in the males shining black: coxæ slate-grey; the thighs black, with a ferruginous apex: tibiæ rufous, the hinder pair with the half next the apex black; tarsi black: wings brown. One line. Meig. *Zw.* pl. xxxvi. fig. 5. Found in France and Germany.

FAMILY XVIII.—OCYPTERÆ.

Antennæ porrect, three-jointed: abdomen consisting of six segments: wings without a transverse nervure, pointed: proboscis concealed.

Genus Lonchoptera, Meig. (Plate CCLI. figures 21 and 21 *a*). Antennæ with the basal joint thickened at the apex, second cup-shaped, third sub-orbicular, compressed, with an elongate three-jointed villose seta at the apex: proboscis retracted: abdomen linear, elongate: wings lanceolate, incumbent, without transverse nervures. Meig. *Zw.* iv. pl. xxxvi. f. 6–13.

L. *tristis*. Forehead dusky black; wings smoke colour: under side of the head yellow: thorax shining black, the sides yellow: abdomen black, the terminal segment of the males with yellowish lamellæ: legs yellow; the hinder tibiæ somewhat clavate, stouter in the male than in the other sex: halteres white. Has been taken by Dr Leach in England, and occurs in the vicinity of London. *L. lutea*, known by its yellow colour, and a narrow black line along the whole length of the back, has recently been observed in Dumfriesshire and some other southern counties of Scotland.

FAMILY XIX.—SCENOPINII.

Antennæ deflexed, three-jointed; the third joint truncated and without bristles: proboscis concealed: abdomen consisting of eight segments.

Genus Scenopinus, Lat. (Plate CCLI. figures 22 and 22 *a*.) Antennæ sub-deflexed, three-jointed, the lower joints small, third elongate, sub-cylindric, truncated, without a seta: proboscis retracted and concealed: abdomen linear, flat, eight-ringed: wings incumbent, parallel.

S. *vitripennis*. Head glossy black: body black; thorax with a faint metallic lustre: halteres brown: head white beneath: legs yellowish red: wings hyaline. One and a half line. Not common. Near Moffat.

FAMILY XX.—CONOPSARIÆ.

Antennæ porrect, three-jointed, angular at the base: proboscis porrect, geniculated: thorax without a transverse suture: abdomen consisting of five or six segments: halteres naked: wings incumbent. Meig. *Zw.* iv. xi.

Genus Conops, Linn. (Plate CCLI. figures 23 and 23 *a*.) Antennæ approximating, the first joint cylindric, second and third clavate, the apex with a two-jointed style: proboscis standing out, filiform, geniculated at the base: ocelli wanting: wings incumbent, parallel.

C. *flavipes*. Antennæ black; head rufous, with a reddish-brown inflated vesicle on the crown, in front of which there is a black line; from this a black vitta extends to the antennæ, where it becomes wider, but does not reach the margin of the eyes: thorax deep black, with a yellow spot on each shoulder, and another on each side behind under the base of the wing: scutellum black, margined with yellow: abdomen sub-cylindric, slightly clavate behind, black; the second and third segments in the male, and the fourth also in the female, with a bright yellow band behind; the basal segment with a yellow spot on each side; the two terminal ones ash-grey: halteres rufous: legs yellow; thighs black, yellow at the base; apex of the tarsi brown: wings with the anterior margin more or less brownish. Five lines. *C. flavipes*, Linn.; *C. macrocephala*, *Samou. Comp.* pl. ix. fig. 8. Upwards of twenty species have been described as belonging to this genus, only six of which have been ascertained to inhabit Britain. They are usually found on flowers, and seldom occur in large numbers. The individual described is found not unfrequently in the south of England, and occurs sparingly during the autumn in Roxburghshire, and the neighbourhood of Edinburgh, generally on the flowers of *Senecio Jacobæa*.

Con. melanocephala of one of Meigen's earlier works was merely a specimen of the above in which the head had become black.

It appears that the females of these insects deposit their eggs in the larvæ of humble-bees (*Bombus*), or even in the bodies of the perfect insects. Latreille, indeed, has frequently observed them issue from the abdomen of the latter. MM. Lachat and Audouin presented a memoir to the *Société Philomatique*, on an apodal larva which they found in the month of July, in the interior of *Bombus lapidarius*, and which they deemed the larva of *Conops flavipes*.[1] Bosc seems to have also noticed this parasite, but he mistook it for an intestinal worm properly so called.[2]

Genus Zodion, Lat. Antennæ with the basal joint cylindric, second clavate, compressed at the base, third ovate, the back with a style: ocelli three: proboscis standing out, filiform, elongate, geniculated at the base: wings parallel, incumbent.

Z. *cinereum*. Hypostoma pale reddish yellow, the margin of the eyes white, the latter colour extending half way up the forehead: forehead reddish yellow anteriorly, passing into dark brown above: antennæ black, the third joint rufescent, with a blackish apex; sometimes the second joint is likewise rufescent anteriorly: thorax cinereous, with four blackish longitudinal lines on the back, of which the two central ones are abbreviated, the sides and hinder part spotted with black: abdomen cinereous,

[1] See *Mém. de la Soc. d'Hist. Nat.* t. i. p. 330, pl. xxii.

[2] *Diction. Class. d'Hist. Nat.* t. iv. p. 404.

the incisures from the second to the fourth marked with a cross row of elevated black points; the back sometimes with four blackish evanescent spots: anal segment of the males shining black: legs cinereous, the tarsi blackish: wings somewhat brownish, slightly ferruginous at the base. Three lines. Meig. *Zw.* iv. pl. xxxvii. figs. 6, 7; *Myopa cinerea*, Fab.; *Zodion conopsoides*, Lat. Usually found on umbelliferous flowers. It is an inhabitant of England, France, and various parts of the continent of Europe.

Genus Myopa, Fab. Antennæ with the basal joint cylindric, second clavate, compressed at the base, third globose, with a dorsal style: ocelli three: proboscis standing out, filiform, elongate, geniculated at the base and middle: wings incumbent, parallel. Meig. *Zw.* iv. 140.

M. *buccata.* Hypostoma white, without spots; forehead dark brown, with grey spots; antennæ testaceous, third joint reddish yellow: thorax spotted with black and cinereous: shoulders testaceous: scutellum dark brown: abdomen testaceous or reddish brown, spotted with grey on the sides: legs testaceous; thighs blackish before the apex: tibiæ with a dark-brown ring at the middle, and another at the apex; tarsi rufous: wing-scales white: halteres pale yellow; wings clouded with pale brown, the small cross nervure not darker coloured. Meig. iv. 142. *Conops buccata*, Linn. Occurs at times on umbelliferous flowers, in gardens and fields, throughout England and the south of Scotland. Botanic Garden, Edinburgh. *M. picta*, which does not differ much from the above, is likewise found in similar situations near Edinburgh.

FAMILY XXI.—STOMOXIDÆ.

Antennæ deflexed, three-jointed, obtuse beneath: third joint with a dorsal seta: proboscis porrect, geniculated: abdomen consisting of four segments: halteres covered with a double wing-scale. Meig. *Zw.* iv. xi.

Genus Siphona, Meig. Antennæ with the lower joints small; third elongate, linear, obtuse; the base with a naked dorsal seta: proboscis exserted, horizontal, filiform, geniculated at the base and middle: wings divaricating. Meig. *Zw.* iv. 154.

S. *tachinaria.* Thorax and scutellum pale cinereous; the abdomen nearly conical, pale ferruginous; the first and second segments pellucid at the sides, the incisures whitish, with small wart-like spots: thorax, scutellum, and abdomen of the females likewise pale ferruginous; the latter elliptical, and the sides not so clearly pellucid; legs ferruginous, with brown tarsi. Two lines. Meig. *Zw.* pl. xxxvii. fig. 25; *Stomoxys cristata*, Fab. Inhabits Europe. Has been found in England, but is very scarce.

Genus Stromoxys, Fab. (Plate CCLI. figures 27 and 27 *a*); from στομα, *the mouth*, and οξυς, *sharp*. Antennæ incumbent, with the lower joints small; third elongate, compressed, linear, obtuse, with a dorsal seta at the base; proboscis standing out, horizontal, geniculated at the base; wings divaricating.

S. *calcitrans.* Hypostoma yellowish white: proboscis stiff, porrect, shining black beneath, with filiform, short, ferruginous palpi: forehead wide with a black line, somewhat narrower in the males than in the females: antennæ brown, with a seta which is plumose on one side: thorax cinereous, with short hairs and a black line along the back: abdomen rounded, covered with short hairs, cinereous, with shining black spots: legs black brown: wing-scales white: wings uncoloured. Three lines. *Conops calcitrans*, Linn.; Degeer, *Ins.* vi. 39, 11; *Musca pungens*, pl. iv. fig. 12–18. Not unfrequent throughout Britain. This is the common well-known stinging-fly, which, in hot and sultry summer days, persecutes men and beasts with its painful bite. It attacks the legs in preference to any other part of the body. Even horses and cattle are not protected by their thicker hides. It is said to be most annoying before a storm. The *C. calcitrans* is so like a common house-fly, as to have induced the erroneous belief that the latter is also a blood-sucker. The females lay their eggs in dunghills. According to the observations of MM. Lepelletier and Serville (*Encyclop. Méth.*), many individuals survive the winter in a state of torpidity,—twenty having been sometimes found together in a mass, within the hollow of a tree.

FAMILY XXII.—ŒSTRACIDES.

Antennæ small, three-jointed; the third joint with a naked seta: mouth closed up, without a distinct proboscis: abdomen pubescent, consisting of four or five segments. Meig. *Zw.* iv. xi.

Genus Œstrus, Linn. (Plate CCLI. figures 24 and 24 *a*.) Antennæ with the lower joints minute, the third globose, with a naked seta: mouth closed:[1] halteres covered: wings spreading, the apex with a transverse nervure.

Œ. *ovis.* Hypostoma flesh red: forehead dusky red, with a reddish line, and blackish depressions: antennæ black: thorax cinereous, sprinkled with small blackish warts, each of which supports a fine hair; on the neck these warts form lines: scutellum pale brown, with blackish warts placed without order: abdomen arched, rounded, obtuse, silky white, with a yellowish play of colour in some places, and prettily sprinkled with irregular spots of a deep shining black: legs pale red: wing-scales large and white: wings clear hyaline, with a blackish transverse nervure at the middle. Five lines. Meig. *Zw.* pl. xxxviii. fig. 16; Linn. Fab.; Réaumur, *Ins.* iv. *Mém.* xii. tab. xxxv. fig. 10–15; Clark, *Linn. Trans.* iii. tab. xxiii. fig. 14–17. Of the nine European species of Œstrus, as now restricted, only three inhabit Britain, viz. the one above described, and *Œ. pictus* (Curtis, *Brit. Ent.* iii. pl. cvi.), and *Bovis*. *Œ. ericetorum* of Dr Leach is not regarded by Meigen as essentially distinct from that last named.

The injury and annoyance which the insects of this genus, familiarly known under the names of breeze, gadfly, &c. cause to sheep and cattle, render them deserving of our careful consideration. Mr Bracy Clark, to whom we still owe the best account of their economy,[2] procured, about the middle of June, some full-grown larvæ of *Œ. ovis*, from the inside of the cavities of the bone which

[1] Meigen's expression, *mund geschlossen*, is obscure. It has in fact been doubted whether the insects of this and the following genus had any mouths. Linnæus says, " Os nullum punctis tribus;" but, according to Mr Bracy Clark, when the hairs, which in all the species greatly obscure the oral organs, are removed, two clavated *palpi* are seen, and between the opening of the mouth;—"and by laying open the vesicular or inflated part of the face, the continuation of it is visible in the form of a membranous *haustellum*, which is generally coloured with some dark-brown matter lodging on the inside: though I confess, after repeated dissections, I have not been able to trace this haustellum farther than the inside of the inflated part of the head, where it appears to enlarge and terminate. Fabricius has minutely described labia to the haustellum, and other apparatus to the mouth, which I have not been fortunate in obtaining a sight of. At the same time I cannot help being surprised that he should have overlooked the *palpi*, which he expressly denies the existence of, though tolerably visible even without the aid of glasses." (*Linn. Trans.* vol. iii. p. 322.)

[2] *Observations on the Genus Œstrus, Linn. Trans.* vol. iii. p. 289; see also the author's later work, *An Essay on the Bots of Horses and other Animals*, 4to, 1815. It is quoted and referred to by a recent French writer under the title of " The Bost of Horse!"

supports the horns of the sheep. They were nearly an inch long, of a delicate white colour, flat on the under side, and convex on the upper; having no spines at the divisions of the segments of the body, though provided with tentacula at the smaller end. When young they are entirely white, but as they increase in size their upper side becomes marked with two transverse brown lines on each segment, and some spots become visible upon the sides. They move with considerable quickness, holding with the tentacula as a fixed point, and drawing up the body towards them. There is a broad line of dots on the under surface, which appear as rough points under a microscope, and probably serve both for locomotion, and for exciting such a degree of inflammation in the membrane on which they rest, as to cause the secretion of lymph or pus. Mr Clark has usually found these larvæ in the horns or frontal sinuses, though he has remarked that the membranes of those cavities were scarcely at all inflamed, while those of the maxillary sinuses were highly so. From this he is led to suspect that they inhabit the maxillary sinuses, and crawl, on the death of the animal, towards the horns and frontal sinuses. In common with *Œ. Bovis*, they do not seem confined to any particular season, for young and old are found together at the same time. When full grown they fall through the nostrils, and change to the pupa state, lying on the earth, or adhering by the side to a blade of grass. The fly bursts the shell of the pupa in about two months.

The manner in which the perfect insect lays its eggs is difficult to determine, owing to its obscure colour and extremely rapid movements. The great agitation of the sheep also interferes with accurate observation, but its general motions and method of defence leave little doubt that the eggs are deposited on the inner margin of the nostril. "The moment," Mr Clark observes, "the fly touches this part of the sheep, they shake their heads, and strike the ground violently with their fore feet; at the same time, holding their noses close to the earth, they run away, looking about them on every side, to see if the fly pursues; they also smell to the grass as they go, lest one should be lying in wait for them. If they observe one, they gallop back, or take some other direction. As they cannot, like the horses, take refuge in the water, they have recourse to a rut, or dry dusty road, or gravel pits, where they crowd together during the heat of the day, with their noses held close to the ground, which renders it difficult for the fly to get at the nostril." Mr C. imagines that the last-named part, from the constant attacks, and the consequent rubbing upon the ground, becomes inflamed and painful, which occasions their touch to be so greatly dreaded by the sheep.

The *Œstrus Bovis*, in the perfect state, is a very beautiful insect, and one of the largest of the European species. The wings are without spots; the abdomen has a central band of black, and is clothed at the extremity by reddish-yellow hairs. Although its effects on cattle have been often remarked, yet the fly itself, as Mr Clark has observed, is rarely seen or taken, "as the attempt would be attended with considerable danger." It inflicts greater pain in depositing its eggs than any other species. "When one of the cattle is attacked with this fly, it is easily known by the extreme terror and agitation of the whole herd: the unfortunate object of the attack runs bellowing from among them to some distant part of the heath, or the nearest water, while the tail, from the severity of the pain, is held with a tremulous motion straight from the body, in the direction of the spine, and the head and neck are also stretched out to the utmost. The rest, from fear, generally follow to the water, or disperse to different parts of the field. And such is the dread and apprehension in the cattle, of this fly, that I have seen one of them meet the herd when almost driven home, and turn them back, regardless of the stones, sticks, and noise of their drivers; nor could they be stopped till they reached their accustomed retreat in the water. When oxen are yoked to the plough, the attack of this fly is attended with real danger, as they become perfectly uncontrollable, and will often run with the plough directly forwards, through the hedges, or whatever obstructs their way." The attack of this small but dreaded foe has indeed been often described, and by none with more of taste and accuracy than by the "Mantuan Bard."

> Est lucos Silari circa, ilicibusque virentem
> Plurimus Alburnum volitans, cui nomen Asilo
> Romanum est, Œstron Graii vertere vocantes:
> Asper, acerba sonans: quo tota exterritu sylvis
> Diffugiunt armenta; fusit mugitibus æther
> Concussus, sylvæque et sicci ripa Tanagri.[1]

The female deposits her eggs with great rapidity, and does not remain above a few seconds on the back of the animal. The larvæ live beneath the skin, between it and the cellular membrane, in a proper sack or abscess, rather larger than the insect. When young they are smooth, white, and transparent, become darker as they increase, and when full grown are of a deep-brown colour. After a time they work their way out, fall to the ground, and assume the state of chrysalis, in which they continue from about the latter end of June till towards the middle of August, when the perfect insect makes its appearance.

Genus Gastrus, Meig.; *Œstrus*, Linn.; *Gasterophilus*, Leach. (Plate CCLI. figures 25, 28, and 28 *a*.) Antennæ with the lower joints small, the third compressed and furnished with a naked dorsal seta: mouth closed: halteres naked: wings without a transverse nervure at the apex. Meig. *Zw.* iv. tab. xxxviii. fig. 18–23.

G. *Equi.* Head with fine hairs, yellowish grey, the forehead rather darker, with two reddish-brown vittæ: antennæ ferruginous: thorax anteriorly with ferruginous pubescence, that on the hinder part of a darker colour, the sides with rather long glistening hairs passing into whitish yellow: scutellum with black pubescence behind: abdomen ferruginous, the pubescence fine, with a silky gloss; the back with a triangular blackish spot on each of the segments, and sprinkled with several small spots, at least in the male: legs and halteres ferruginous: wing-scales white: wings whitish; having a waved brownish-grey band across the middle, and two spots of the same colour at the apex: the ovipositor of the females is thick, cylindrical, and of a shining black colour. Five lines. Meig. *Zw.* iv. pl. xxxviii. 21, 22; *Œs. Bovis*, Linn.; *Œ. Equi, Linn. Trans.* iii. 298, pl. xxiii. f. 7–9.

Not common in Britain. This species, likewise known by the name of breeze or gad-fly, usually frequents elevated heathy districts, and we have observed it flying about the summits of the Westmoreland hills,[2] and those of Roxburghshire. Mr Bracy Clark has also furnished us with some valuable information on the manners and metamorphosis of this insect, the larvæ of which are com-

[1] *Georg.* lib. iii.

[2] On one occasion particularly, on crossing some hill pasture above Elleray, the seat of Professor Wilson, we were suddenly attacked by three of these insects. They flew round about us in a state of angry excitement, coming sometimes within a few inches of the face, and keeping so close to each other, that, having the forceps in hand, we captured the whole three at once, to their great surprise, and probably disappointment.

monly called *bots*. "The mode pursued by the parent fly to obtain for its young a situation in the stomach of the horse is truly singular, and is effected in the following manner:—When the female has been impregnated, and the eggs are sufficiently matured, she seeks among the horses a subject for her purpose, and approaching it on the wing, she holds her body nearly upright in the air, and her tail, which is lengthened for the purpose, curved inwards and upwards: in this way she approaches the part where she designs to deposit the egg, and suspending herself for a few seconds before it, suddenly darts upon it, and leaves the egg adhering to the hair: she hardly appears to settle, but merely touches the hair with the egg held out on the projected point of the abdomen. The egg is made to adhere by means of a glutinous liquor secreted with it. She then leaves the horse at a small distance, and prepares a second egg, and, poising herself before the part, deposits it in the same way. The liquor dries, and the eggs become firmly glued to the hair: this is repeated by various flies till 400 or 500 eggs are sometimes placed on one horse. The horses, when they become used to this fly, and find it does them no injury, as the *Tabani* and *Conopes*, by sucking their blood, hardly regard it, and do not appear at all aware of its insidious object."[1] The inside of the knee is the part usually chosen, although other places are sometimes selected. It is worthy of note, however, that these ova are always laid where they are most liable to be licked off by the horse's tongue. It is not, however, precisely the eggs themselves which are conveyed into the interior of the animal. Mr Clark found that after they have remained four or five days on the hairs, they became *ripe*,—after which the slightest application of warmth and moisture is sufficient to bring forth the latent larva in an instant. "At this time, if the tongue of the horse touches the egg, its *operculum* is thrown open, and a small active worm is produced, which readily adheres to the moist surface of the tongue, and is from thence conveyed with the food to the stomach." Mr Clark has often clipped off some hairs with eggs on them, and holding them in his hand, moistened with saliva, has seen them hatched in a few seconds. If the larvæ pass the dreadful ordeal of mastication, and are transmitted uninjured to the horse's stomach, they attach themselves to every part of it, but are generally most numerous about the *pylorus*. Sometimes, but much less frequently, they occur in the intestines. Their numbers are very various,—from half a dozen to above a hundred. They generally hang in clusters, being fixed by the small end to the inner membrane of the stomach, to which they adhere by means of two small hooks or *tentacula*. When removed from the stomach they will attach themselves to any loose membrane with which they may come in contact, and even to the skin of the hand. On attaining to their full size, they pass by the intestinal canal, drop to the ground, and enter the chrysalis state. Upon the whole, Mr Clark does not regard these insects as hurtful to horses, but rather views them favourably, as natural *stimuli*. Valisnieri, however, considered them as the cause of the epidemic malady which in 1713 carried off so many horses in the territories of Mantua and the Veronese.[2]

Four other species are found in Britain, besides the one to which the preceding observations more particularly apply,—viz. *Œ. hæmorrhoidalis, nasalis, Clarkii*, and *salutiferus*.[3]

FAMILY XXIII.—MUSCIDES.[4]

Antennæ inclined, three-jointed, obtuse beneath: the third joint with a seta on the back: proboscis concealed, geniculated at the base: thorax with a transverse suture: abdomen having from four to six segments. Meig. *Zw.* iv. xi.

Genus Xysta, Meig. Antennæ incumbent, shorter than the hypostoma, second and third joints nearly equal, compressed; the terminal one with a naked dorsal seta at the base: mouth with a mystax: abdomen convex, consisting of five or six segments: wings divaricating.

X. *cilipes*. Hypostoma and forehead greyish white, the last with a black line: palpi ferruginous, the apex brown: thorax dark grey, with three blackish lines: abdomen shining black, consisting of six segments; the two terminal segments grey, the apex having a shining black bent appendage: legs black, strong: the hinder tibiæ arched, dilated, and fringed with long black bristles: wing-scales white; halteres slender, black: wings hyaline, yellowish at the base. Three and a half lines. Meig. *Zw.* iv. 182, pl. xxxix. f. 5.

Two species only belong to this genus, both of which appear to be scarce on the continent, and neither of them has been observed in Britain.

Genus Phasia, Lat. Antennæ incumbent, shorter than the hypostoma, third joint rather longer than the second, obtuse; the base with a naked dorsal seta: mouth villose: abdomen depressed, pubescent, consisting of five segments: wings divaricating. Meig. *Zw.* iv. pl. xxxix. f. 6–16.

P. *subcoleoptrata*. Hypostoma whitish, with a pearly play of colour; forehead white, with a changeable dark grey line; antennæ blackish brown; thorax light grey, with four black lines, the two central ones abbreviated behind: scutellum cinereous: abdomen oval, flat, black brown in the male, with cinereous, and sometimes reddish-brown reflections, the apex golden yellow: that of the female black brown, with a dark dorsal line: wing-scales of the male brownish, of the female white: legs blackish: wings of the male broad, yellowish at the base, the anterior margin having a brown vitta extending rather beyond the middle, and there is another of the same colour along the centre, which is dilated at the apex so as to appear somewhat curved forwards; wings of the female comparatively narrow, hyaline, somewhat yellowish at the base. Male four, female three lines. Meig. *Zw.* iv. 190, pl. xxxix. f. 13.

Occurs in the northern parts of the continent of Europe and in Britain, but appears to be rare. *P. hemiptera, semicinerea*, and *pusilla*, are the only other kinds hitherto found in Britain, although the genus contains upwards of thirty species.

Genus Gymnosoma, Meig.; from γυμνος, *naked*, and σωμα, *the body*. Antennæ with the second and third joints nearly equal; the terminal one compressed, linear, obtuse, with a naked dorsal seta at the base: mouth naked: abdomen nearly naked, globose, consisting of four segments: wings spreading. Meig. *Zw.* iv. pl. xxxix. f. 17–22.

[1] See *Linn. Trans.* vol. iii. p. 298; and the Essay mentioned in preceding note.

[2] *Ragionamento intorno all' Œstre de Buoi.* Opere, t. i.

[3] Stephens' *Systematic Catalogue*, part ii. p. 296.

[4] The tribe Muscides of Latreille (excepting, we believe, the genera *Diopsis, Scenopina*, and *Achias*) has been recently created into a separate order, named Myodariæ, by M. Robineau Desvoidy. See an abstract of his views in the *Diction. Class. d'Hist. Nat.* t. xi. p. 365.

G. *rotundata*. Male. Hypostoma straw-colour, silky: forehead golden yellow, with a brownish vitta changing into red: antennæ black; the third joint ferruginous on the inner side at the base; thorax dull-ferruginous, with four brownish longitudinal lines, and a shining black transverse band behind: scutellum black: abdomen ferruginous, pellucid, with black spots on the back: legs black: wings brownish, ferruginous at the base: wing-scales dirty white.

Female. Hypostoma and forehead pearl-white; the frontal vitta brown: thorax cinereous on the sides and beneath. Four lines. *Musca rotundata*, Linn. Fab.; *Ocyptera rotundata*, Lat. On flowers and shrubs: found near London, and on the continent, not unfrequently.

Genus Ocyptera, Meig. (Plate CCLI. figures 26 and 26 *a*.) Antennæ somewhat deflexed, third joint longer than the second, linear, compressed, obtuse, having a naked dorsal seta at the base: mouth furnished with a mystax: abdomen elongate, cylindric, subsetose, four-ringed: wings spreading. Meig. *Zw.* iv. pl. xxxix. f. 23–29.

O. *brassicaria*. Hypostoma and forehead silky white, the former with two narrow black lines, the latter with a broad black vitta: antennæ blackish: thorax anteriorly slate grey, with four black lines, the two in the centre narrow: abdomen with the first and second segments sanguineous, the former with a large triangular mark of black on the back, the two terminal segments black, the penultimate one silvery on the anterior margin: legs black: wing-scales pale white: wings brownish grey, the base ferruginous. Five to six lines. Meig. iv. 211, pl. xxxix. f. 29. Apparently a scarce species. It occurs near Edinburgh.

M. Leon Dufour, in a memoir on the insects of this genus, has shown that the larvæ of two species, *O. cassidæ* and *bicolor*, are parasitical,—the first in the visceral cavity of *Cassida bicolor*, the second in that of *Pentatoma grisea*. Each feeds upon the epiploon or fatty matter of his host.[1]

Genus Lophosia, Meig. Antennæ deflexed, the two basal joints minute, the third very large, compressed, triangular, with a naked dorsal seta at the base: mouth with a mystax: abdomen cylindric, composed of four segments: wings spreading. Meig. *Zw.* iv. pl. xl. f. 1–4.

L. *fasciata*. Hypostoma silky white; antennæ with the two first joints black, the third brown: thorax bristly, shining black above, dark grey on the sides, with a changeable cinereous spot on each shoulder: abdomen sub-cylindric, arched, slightly narrowed at the base, bristly, of a shining black colour, the anterior margin of the second and third segments changeable white: thighs black, somewhat pubescent, bluish white beneath, with a naked white spot on the inner side at the apex; anterior tibiæ blackish brown, posterior rufous: tarsi black: wings hyaline, with a broad obsolete cross band of a brownish colour before the apex. Five lines.

This genus is readily distinguishable from all the allied genera by the large and distinctly trigonate terminal joint of the antennæ. It contains but one species, which occurs on the continent.

Genus Phania, Meig.; named from φανος, because most of the species are pellucid. Antennæ deflexed, third joint elongate, linear, compressed, obtuse; the base with a naked dorsal seta: mouth with a mystax: abdomen consisting of four segments, the apex elongate, and bent inwards: wings spreading. Meig. *Zw.* iv. pl. xl. f. 5–10.

P. *curvicauda*. Head silver white, with a black play of colour: palpi and antennæ black brown; the third joint with a finely pubescent seta, thickened at the base; forehead with a deep black line, broadest in the female: body shining black, bristly, except on the shoulders, where there are white spots: wing-scales white: halteres black brown; wings brownish grey, the base yellowish: legs black. Meig. iv. 221, pl. xl. f. 10. Rare: it occurs in Britain along with two other species, *P. vittata* and *thoracica*.

Genus Trixa, Meig. Antennæ incumbent, short; second and third joints equal, terminal ovate, having a naked dorsal seta at its base: hypostoma villose, without a mystax: wings spreading, with a transverse nervure at the apex. Meig. *Zw.* iv. pl. xl. f. 11–16.

T. *dorsalis*. Hypostoma cinereous; palpi and antennæ black brown: thorax ash grey, with four black lines: scutellum black: abdomen rufous, having a broad dorsal line of black, which at the base of the segments changes with a play of colour into whitish grey; the third and fourth segments have a similar play of colour on the sides; wing-scales white: wings greyish; the small cross nerve of the middle rather thick, black, edged with brown: legs black; tibiæ and tarsi faintly rufescent. Five lines. Inhabits Britain, but is scarce. Only one other species of the six described by Meigen is known to be British,—*T. variegata*, which has occurred in the neighbourhood of London, in Dumfriesshire, and near Edinburgh.

Genus Miltogramma, Meig. Antennæ incumbent, third joint elongate, linear, compressed; the base with a naked dorsal seta: mouth setose: wings spreading, the apex with a transverse nervure. Meig. *Zw.* pl. xl. f. 17–26.

M. *fasciata*. Hypostoma white, with flesh-coloured play of colour: palpi and antennæ clear reddish yellow; the frontal vitta rather broad: thorax and scutellum cinereous, with three black lines: abdomen conical, the first segment black, the following white anteriorly, and banded with black behind; on the sides the white passes with a play of colour into brownish red: legs black: wing-scales white. Four lines. Meig. iv. 227, pl. xl. f. 26.

The males have been found in Germany, the females are unknown.

Genus Tachina, Illig. Antennæ deflexed or incumbent, the third joint truncated beneath; the base with a naked dorsal seta: mouth with a mystax: wings spreading, having a transverse nervure at the apex. Meig. *Zw.* iv. 234, pl. xl.

T. *grossa*. Head ferruginous, with a brown frontal line changing into ferruginous; palpi ferruginous, with black bristles; antennæ blackish brown at the base; second joint ferruginous, third sub-quadrate, brown with a yellowish play of colour: seta black: body shining black: wing-scales dark brown: wings greyish, the base ferruginous: legs black. Eight lines. Meig. iv. 239. *Musca grossa*, Linn.; *Echinomyia grossa*, Lat. Found occasionally in most parts of Britain. We took it in Sutherland. It is one of the largest of the European Diptera. The larva lives in the dung of cattle, and is described by Réaumur. We may observe that the genus Tachina, notwithstanding the labours of recent writers, is still a great magazine of ill-assorted species. Considerably above three hundred occur in Europe.

Genus Gonia, Meig.; from γωνια, *an angle*, referring to the form of the antennal seta. Antennæ deflexed, incumbent, the third joint elongate, prismatic, the base with a naked seta, which is three-jointed and geniculate:

[1] *Annales des Sciences Nat.* t. x. p. 248. See also *Règne Animal*, t. v. p. 513.

eyes remote: wings spreading, the apex with a transverse nerve.

G. *capitata*. Head reddish-yellow, with a whitish play of colour; palpi ferruginous; antennæ dark brown; the second joint ferruginous: thorax blackish, passing into brown on the back, with an ash-grey play of colour, and marked with four black lines; scutellum brownish yellow: abdomen pellucid, ferruginous, shining, with an indistinct dorsal line of black; the first and second incisures have a very narrow, and the third a wider edge of changeable whitish yellow: belly ferruginous; legs black: wing-scales white: wings somewhat grey, with the base yellowish. Six to seven lines. *Musca capitata*, Degeer, *Ins.* vi. 12, 2.

This genus is of limited extent, not including more than a dozen species. Two of these, besides the above, occur in Britain, but are by no means common. *G. capitata* seems to be most plentiful in Sweden.

Genus Zeuxia, Meig. Antennæ incumbent, the second and third joints equal, the third or terminal one compressed and obtuse, having a plumose dorsal seta at the base: mouth with a mystax, and clavate projecting palpi: wings spreading, the apex with a transverse nerve.

Z. *cinerea*. Hypostoma white: forehead wide, bristly, white with a small black line: palpi extended horizontally, large and clavate, ferruginous; antennæ brown: thorax bristly, having a suture across the back, the colour pale grey, with four black lines anteriorly, and three behind, the central ones much narrower than those at the sides: abdomen bristly, conical, four-ringed, and of an ash-grey colour changing into brown: legs black: wing-scales large, the halteres covered: wings nearly hyaline. Three lines. Has been found in Germany.

Genus Idia, Meig. Antennæ incumbent, the third or terminal joint oblong, having a dorsal seta at the base, plumose on one of the sides: palpi projecting, clavate: wings with a transverse nerve at the apex.

I. *fasciata*. Hypostoma shining black, spotted with white, and not furnished with a mystax: antennæ shorter than the hypostoma, and of a brown colour: thorax ash-grey, the colour playing into black, with three broad lines of black down the middle: scutellum grey, with a blackish play of colour: abdomen oval, black, with three rufous interrupted bands: belly yellowish red: legs black: wing-scales white, entirely covering the halteres: wings greyish. Three lines. Has been found at Marseilles, and on the hills near Frejus, but is very rare.

Genus Mesembrina, Meig. The generic term is a Greek word signifying meridian. Antennæ incumbent, the third or terminal joint oblong, prismatic, having a plumose dorsal seta at the base: body hirsute: wings spreading, and furnished with a transverse nerve at the apex.

M. *meridiana*. Hypostoma black, with a large angular spot of a bright gold colour on each side: forehead shining black, with a dull black streak: palpi black: antennæ dark brown, the seta ferruginous at the base: body and legs shining black; the two last joints of the anterior tarsi brown in the males, all the onychii yellow: halteres brown: wing-scales, and likewise the base of the wing, ferruginous. Six lines. *Musca meridiana*, Linn. Fab. Common throughout Britain during the summer and autumnal months, on flowers and in woods—often seen resting on the stems of trees.

The larva of this species lives in cow-dung. It is yellow, conical, and composed of many segments. At the mouth or narrowest end it has only one hook, and four short fleshy horns or warts. The hinder end or anus is, as it were, four-cornered and truncated, and has two circular brown spots, which are slightly raised, and are each perforated by a single air-hole. The two anterior air-holes are placed on the sides of the first segment. The larva changes itself in its own skin into a dark-brown nymph, which is nine-cornered behind, or nearly circular, and the posterior air-holes are observable. In summer the fly appears in a few weeks, but the nymphs formed late in the season continue throughout the winter, and produce the perfect insect in the spring.

The species of this genus are not regarded as generically distinct by Latreille, but form part of his genus *Musca*, or *Mouches proprement dites*.

Genus Sarcophaga, Meig. Named from σαρξ, *flesh*, and φαγω, *I eat*. Antennæ incumbent, the third or terminal joint oblong, prismatic, the base with a plumose seta, naked at the apex: eyes not united: wings spreading, and furnished with a transverse nerve at the apex. Meig. *Zw.* v. 14, pl. xliii. fig. 1–10.

S. *mortuorum*. Head silky golden yellow, with a reddish play of colour; palpi ferruginous; antennæ fulvous, changing into whitish grey; line down the forehead reddish brown, changing into golden yellow: thorax blackish, with a grey play of colour, and black lines: abdomen shining steel blue; belly and legs black: wing-scales white: wings greyish. Five to six lines. *Musca mortuorum*, Linn. Fab. Frequent in the south of Scotland, in England, and apparently throughout the north of Europe, except Germany, where it is said to be rare.

In this genus the eggs are not unfrequently hatched within the body of the mother, which has induced their being regarded as viviparous,—strictly, *ovoviviparous*. Of this kind is the *S. carnaria* (*Musca carnaria*, Linn.), a species somewhat larger than the common flesh-fly (*M. vomitoria*). The female deposits her living larvæ on meat, carcasses, and even on wounded or diseased subjects of the human race.

Genus Dexia, Meig. Antennæ incumbent, the third or terminal joint elongate and compressed, with a densely plumose seta at the base: abdomen conical (in the male) or oblong-elliptical (in the female): wings spreading.

D. *compressa*. Hypostoma of a shining silvery hue, with a black play of colour; forehead shining black, with a deep-black vitta; palpi rufous; antennæ nearly the length of the hypostoma, slender, the seta with a short plume: thorax bluish grey, with two wide shining black lines, which are continued over the grey scutellum to the sides: abdomen somewhat compressed on the sides, shining rufous, with a blackish line on the back spotted with grey; the incisures bright silver white, with a play of colour; legs black, with rufous thighs: wing-scale large and white: wings with a marginal spine, brown, clouded, and yellow at the base. Four to five lines. *Ocyptera rufa*, Fab.; *Musca rufiventris*, Fallen. Rather scarce: has been found in Germany, Spain, England, and some other parts of Europe. Twenty-four species are referred to this genus, fourteen of which seem to be indigenous to Britain.

Genus Musca, Linn. Antennæ incumbent, the third joint elongate, obtuse, compressed in a prismatic form, the base with a plumose dorsal seta: abdomen ovate, setose: wings spreading, the apex with a transverse nerve.

M. *maculata*. Male. Hypostoma white, with a brown play of colour; forehead white, with a blackish vitta, which becomes narrow above; palpi black: thorax whitish, with four broad black lines, the two central ones united behind the cross suture, and drawn over the scutellum in the form of a lozenge; the scutellum having a black spot on the side: abdomen globose, grey, with a light testaceous-red play of colour, and several deep black spots of different form and size: legs black; wing-scales dirty white: wings somewhat brownish

Female. Forehead wide, whitish, with a deep-black double vitta: thorax light grey, the lines narrower than in the male: abdomen light grey, rarely inclining to testaceous; the spots and other characters as in the other sex. Four lines. *Musca maculata*, Gmelin. Degeer. *Ins.* vi. 41, 13. In summer and harvest in hedges and on flowers; not rare. It is frequent in Roxburghshire during the autumn on the flowers of *Senecio Jacobæa.* Many of the insects of this genus are very common. *M. Cæsar*, distinguished by its brilliant golden-green colour, and *M. vomitoria*, commonly called the *flesh-fly*, are abundant on carcasses throughout Europe. The common house-fly, *M. domestica*, is remarkable for its extensive distribution, being found in Pennsylvania, New Orleans, and other parts of the new world.

We may observe in regard to the last-named species, that it is subject to a singular disease, of which the cause is not yet known. A white crust forms upon the abdomen, which becomes greatly distended, and the segments become distant from each other, so as to produce a ringed appearance. In this condition it is frequently found dead, adhering to walls, and sometimes to the stalks or leaves of plants. Its body is at this time filled with a fatty matter, which has been observed to have exploded on all sides through the pores.

Genus Anthomyia, Meig.; from ανθος, *a flower*, and μυια, *a fly*. Antennæ deflexed, the third or terminal joint oblong, compressed, obtuse, the base with a plumose, pilose, or naked seta; the frontal vitta obscure, narrowed above in the male: mouth with a mystax: abdomen consisting of four segments, setose: wings spreading or incumbent, without a transverse nerve at the apex.

A. *Angelicæ.* Hypostoma and forehead white, the former with a blackish play of colour: thorax bright grey in the male, inclining to ferruginous in the female: scutellum and abdomen ferruginous, the last without a brown play of colour; the black dorsal line does not extend to the hinder extremity, and in the female it is usually interrupted on the third segment: legs rufous, with brown tarsi. Four lines. *Musca Angelicæ*, Scop. *Ent. Cariol.; Musca deceptoria*, Gmel. Schrank. Abundant in woods in the south of Scotland, and apparently equally plentiful in England.

The genus Anthomyia contains upwards of two hundred European species, more than the half of which have been found in Britain. In addition to the one described above, we may name two other well-known species of the genus *A. meteorica* and *pluvialis*, Linn.

Genus Drymeia, Meig. Antennæ deflexed, the third joint oblong, compressed, obtuse at the apex, with a pubescent dorsal seta at the base; forehead with an obscure vitta; the eyes of the male united: mouth with a mystax: proboscis slightly projecting, the capitulum oblong, and furnished with a hook: abdomen four-ringed, setose: wings incumbent, parallel, without a transverse nerve at the apex.

D. *obscura.* Hypostoma white, with a blackish play of colour; antennæ half the length of the hypostoma, black; thorax shining black, bristly, with a cross suture; that of the female inclining to grey, and having two indistinct longitudinal lines of a dark colour: abdomen rather long, bristly, ash-grey, with spots and a line along the back of changeable black; flat in the male, arched in the female, and acute behind: wing-scales small and white: halteres black: legs of the same colour: wings somewhat brownish. Three to four lines. Found in August and September, not unfrequently, in many parts of the continent. Another insect, presenting generic characters somewhat similar to the above, has been found in England, and is named *D. hispida:* some doubt, however, attaches to the propriety of referring it to this genus.

Genus Eriphia, Meig. Antennæ incumbent, the third joint oblong and compressed, the apex obtuse, and having a naked dorsal seta at the base: mouth very hirsute: eyes of the male united: abdomen four-ringed, the apex very hirsute in the male: wings without a transverse nerve at the apex.

E. *cinerea.* Male. Hypostoma grey, shining white on the sides; forehead black, changing into grey; antennæ black: thorax bristly, rather glossy black, with a faint grey play of colour, and marked with three black lines: abdomen with the first segment black, the following three ash-grey, having a dark-brown play of colour, and a black line on the back; the second and third with a black band behind: wing-scales small, yellowish: halteres black: wings somewhat brownish: legs black. Four lines. Found by M. Baumhauer at Genisberg.

Genus Dialyta, Meig. Antennæ incumbent, the length of the hypostoma, the third joint long, compressed, obtuse at the apex, with a naked dorsal seta at the base: mouth with a mystax: eyes equally remote: abdomen four-ringed, pilose: transverse nerve at the apex of the wing wanting.

D. *erinacea.* Hypostoma silky white, with a black play of colour; forehead shining black, with a deep black vitta changing into whitish grey; palpi black, bristly; the antennæ likewise black: body shining black; thorax somewhat hoary, having two scarcely perceptible longitudinal lines, and a distinct prominence on the shoulders: abdomen of the males rather long, elliptical, flat, arched, somewhat greyish, the incisures and a line on the back black, but very faintly marked; that of the female oval, pointed, much arched, and shining black: wing-scales white; halteres black: wings broad, ferruginous at the base: legs black. Three to four lines. A rare species, the native country of which is not yet known.

Genus Coenosia, Meig. Antennæ incumbent, the third or terminal joint long, linear, compressed, with a seta at the base, which is either plumose, or pubescent, or naked: mouth with a mystax: eyes distant, those of the male somewhat approximating: abdomen four-ringed, setose, clavate at the apex in the male: wings incumbent, without a transverse nerve at the apex. The insects of this genus, which is of considerable extent, are found in hedges and on flowers, the smaller kinds are most abundant among grass. With the exception of the species described below, we are not acquainted with their habits and metamorphoses.

C. *fungorum.* Hypostoma white, changing into brown; forehead black, the hinder part of the head ash-grey; palpi and antennæ black, the seta of the last distinctly plumose: thorax grey, with four black lines, which, however, are often indistinct: abdomen rather long, rufous, sometimes with a brownish dorsal line: legs rufous, with black tarsi: wing-scales and halteres white: wings somewhat clouded. The scutellum is sometimes ferruginous, as well as the shoulders. Three and a half lines. The larva of this insect lives in mushrooms, is four and a half lines long, of a whitish-grey colour, with two hooks on the head, the hinder part thick and obtuse. It undergoes its metamorphosis in the earth.

Genus Lispe, Meig. Antennæ incumbent, the terminal joint elongate, compressed, obtuse at the apex, and having a plumose seta at the base: eyes distant: palpi somewhat projecting, slender, spoon-shaped at the apex: abdomen ovate, four-ringed: wings incumbent.

L. *tentaculata.* Male. Hypostoma silky whitish yellow; the frontal vitta wide, and blackish grey; palpi of a shining silvery hue, with a yellow play of colour: thorax

greyish black, with dark indistinct longitudinal lines: abdomen flat, ovate; the first segment grey, the following black; the second and third segments with a rounded white spot on the back, and another on each side of a triangular form placed at the anterior edge; the fourth having only the two triangular spots: legs black; the anterior tarsi have the first joint somewhat shorter than the second, and black, the rest yellowish; wing-scales and halteres white; wings rather grey.

Female. Hypostoma bright yellow; the spots on the abdomen grey; the legs wholly black, the tarsi all alike. Three lines. *Musca tentaculata*, Degeer. Found in Germany, and various other parts of the north of Europe. In Britain it has occurred near London, and seems to be the only species of the genus belonging to this country.

GENUS CORDYLURA, Fallen. Antennæ deflexed, the terminal joint oblong, compressed, truncated at the apex, the base with a seta, which is either plumose or villose: head sphæroidal, the hypostoma scarcely descending, and furnished with an imperfect mystax; eyes distant, globose: abdomen five or six ringed, that of the male linear and clavate at the apex; wings incumbent, parallel, the length of the abdomen.

C. *pubera*. Hypostoma white; palpi black: antennæ shorter than the hypostoma, black, with a plumose seta: forehead of the male not so wide as that of the female, black, with a greyish-white play of colour, sometimes changing anteriorly into reddish yellow: body bristly, shining black; thorax with a line of changeable white in the middle of the front: the sides of the thorax changing into bluish white: wing-scales and halteres white: wings rather dull, the base and anterior margin ferruginous: thighs black, the tibiæ and tarsi testaceous, the latter in the male spotted on the under side with black. Four lines. *Musca pubera*, Linn. Fab. Meig. *Zw.* pl. xlv. fig. 22, *female*. Of occasional occurrence in the southern parts of England.

GENUS SCATOPHAGA, Meig.; from σκατος, *dung*, and φαγω, *to eat*. Antennæ deflexed, the terminal joint elongate, prismatic, obtuse, the base with a seta, which is either plumose or naked; head spheroidal, the hypostoma descending, and furnished with a mystax: eyes distant, rounded: abdomen five-ringed, linear in the male: wings incumbent, parallel, much longer than the abdomen.

S. *scybalaria*. Hypostoma, antennæ, and frontal vitta rufous, the latter very wide; palpi whitish; thorax brownish yellow, with obsolete lines: abdomen brownish yellow, that of the male thick, and clothed with rufescent hairs; legs ferruginous, pubescent; wing-scales small and yellow: halteres yellow: wings large, ferruginous, with brown nervures, the transverse nerve in the middle black, and usually a little bent. Five lines. *Musca scybalaria*, Linn. Fab. This species is of frequent occurrence in Britain. *S. stercoraria* and *S. merdaria* are among our most common insects, and most of the species described by Meigen, amounting to fifteen in number, are inhabitants of this country.

GENUS DRYOMYZA, Fallen. Antennæ incumbent, approximating, the third or terminal joint oblong, obtuse, prismatic, with a villose seta at the base: head spherical; the hypostoma descending, coarctate, naked, blunt below: eyes remote, rounded: abdomen oblong, five-ringed: wings incumbent, very much longer than the abdomen.

D. *flaveola*. Light ferruginous, shining: hypostoma bright yellow, especially on the sides; antennæ black brown, with a dark-yellowish base, and a long black pubescent seta: thorax with two brownish approximating lines on the back; on the abdomen are likewise four brownish lines, but these, properly speaking, are the interior vessels shining through: legs ferruginous, becoming brownish at the extremity: halteres clear yellow; the wings hyaline. Five lines. *Musca flaveola*, Fab. Not rare in Britain, nor in most other parts of Europe.

GENUS SAPROMYZA, Fallen. Antennæ deflexed, the third or terminal joint oblong, compressed, obtuse at the apex, the base with a seta, which is either shortly plumose or villose: head sub-hemispheric, the hypostoma somewhat descending, naked, flat: eyes distant, rounded; abdomen oblong, five-ringed: wings incumbent, parallel.

S. *rorida*. Entirely pale yellow, the seta of the antennæ short and plumose: hypostoma and incisures of the body whitish: wings of a yellowish tint. Two lines. Found during summer, not unfrequently.

GENUS ORTALIS, Fallen. Antennæ deflexed, oblique, the third or terminal joint oblong, compressed, and having a naked seta at the base: hypostoma arched in the middle, naked; the forehead hirsute; eyes oblong; abdomen five-ringed: wings erect (vibrating).

O. *vibrans*. Hypostoma and forehead very bright orange yellow, with the margin of the eyes whitish: antennæ rufous, with a finely pubescent seta: body shining bluish black: halteres white: wings hyaline, the first longitudinal nerve thick, and of a black colour; the apex of the wing occupied by a triangular blackish-brown spot: legs black. Two and a half lines. *Musca vibrans*, Linn. Fab. Degeer. Don. x. 54, pl. cccxlvi. fig. 3. *Tyrophaga vibrans*, Curtis, *B.E.* fol. 126. This insect, which forms the genus *Seioptera* of Kirby, is of frequent occurrence throughout England and the southern district of Scotland. It is rare in Germany, but is plentiful in Sweden and most other northern countries.

GENUS SEPSIS, Fallen. Antennæ incumbent, the terminal joint oblong, obtuse, compressed, with a naked seta at the base: head globose; the hypostoma flat, and furnished with a mystax; eyes rounded, distant: abdomen four-ringed, petiolate, sub-cylindric, naked: wings erect (vibrating). These lively little insects, which are in constant motion, are found on bushes, in hedges, and among grass, almost everywhere, and are for the most part very common from the first bright warm days of spring to the end of harvest: they probably continue during winter. Their natural history is not known.

S. *cynipsea*. Head shining black; antennæ brown: body shining black, with metallic lustre: legs black; anterior coxæ yellow, the thighs black; tibiæ rufous, inclining to testaceous; and in the hinder legs the base of the thighs is rufescent. One and a half line. *Musca cynipsea*, Linn.; *Micropeza cynipsea*, Lat. Common in England and the south of Scotland. In the vicinity of Edinburgh *S. cylindrica* is common, and we have likewise observed *S. nigripes*, *S. violacea*, and *S. punctum*.

GENUS CEPHALIA, Meig. Antennæ incumbent, the third joint elongate, compressed, gradually attenuated, with a pubescent dorsal seta at the base: hypostoma descending, naked; the proboscis standing out: eyes distant, rounded: abdomen four-ringed: wings . . . .

C. *rufipes*. Hypostoma testaceous; forehead black; palpi black; antennæ blackish brown, rufescent at the base: body black, naked: sides of the thorax, breast, and scutellum testaceous: halteres white, not covered; scarcely a trace of the wing-scales is perceptible; legs slender, testaceous: wings hyaline, the first longitudinal nerve thick and black, the apex with a brown spot. Has been found at Berlin and in Austria.

GENUS LAUXANIA, Lat. Antennæ projecting obliquely, remote, the third or terminal joint elongate, compressed, obtuse, with a shortly plumose seta at the base: hypostoma somewhat descending, impressed in the middle: eyes remote, oblong: abdomen ovate, five-ringed: wings parallel, incumbent.

L. *cylindricornis.* Shining black; eyes during life green, with four purple bands; antennæ projecting straight forwards, longer than the head, dark brown, with a whitish pubescent seta; hypostoma shining black, with the lateral edge glistening white; forehead with a dull-black vitta: wing-scales and halteres black; legs black, the hinder tarsi yellow; wings yellow, black at the base. One and a half line. *Sargus cylindricornis*, Fab.; *Musca chrysoptera*, Schrank. Frequent in summer among grass and brushwood.

Genus Lonchæa, Fallen. Antennæ incumbent, approximating, the third or terminal joint oblong, compressed, obtuse at the apex, and having a naked seta at the base: hypostoma flat, somewhat descending, naked: eyes oblong, the forehead of the male narrow, of the female wide: abdomen ovate, villose, six-ringed: wings incumbent, parallel.

L. *nigrimana.* Male. Antennæ brown, shorter than the hypostoma, the third joint ovate, flat: forehead flat, dull black: body shining greenish black: wings pale yellow: legs black: the middle and hinder tarsi rufescent. Two lines. Found in the vicinity of London, along with eight other species of this genus.

Genus Trypeta, Meig. (Plate CCLI. fig. 29. Antennæ incumbent, approximating, the third joint oblong, compressed, obtuse at the apex, and having a seta at the base which is either naked or pubescent: hypostoma somewhat descending, flat, naked: eyes somewhat rounded, distant; the forehead wide and setose: abdomen five-ringed, the apex obtuse in the male, but furnished with a projecting style in the female: wings erect (vibrating).

T. *Zoë.* Honey-yellow, shining, the metathorax bright black: the wings of the male have two dark-brown spots at the anterior border, the smaller one lying above the small cross nerve, and having a small branch projecting forwards from behind; the other, which is much larger, occupies the apex, extending scarcely beyond the fourth longitudinal nerve: in the female the wings have a large brown spot before the middle, and another at the apex, with a narrow cross band, sometimes interrupted, at other times indistinctly marked, in the space between. Male one and a half, female two lines. In the neighbourhood of Edinburgh, and near Jedburgh; not common.

Several different names have been bestowed on this genus. It is named *Traupanea* by Schrank, and *Tephritis* by Latreille: the latter seems to be most generally adopted. To this genus belongs the insect which, in the Isle of France, is so destructive to the lemon crop, by depositing its eggs in that fruit. Its multiplication is sometimes extreme.

Genus Tetanops, Fallen. Antennæ small, distant, projecting obliquely, the third joint ovate, compressed, the base with a naked dorsal seta: hypostoma reclined, descending, carinated, naked; forehead projecting, flat, naked: abdomen five-ringed, the style of the female incurved and jointed.

T. *myopina.* Hypostoma and forehead greyish white; antennæ reddish yellow: thorax light grey, the scutellum of a similar hue: abdomen in the male with the two first segments light grey, unspotted, the two following shining black, having the hinder margin and a line on the back grey, the fifth entirely black; in the female it is light grey, with a black spot on each side of the segments: legs reddish yellow; wings hyaline, with light-brown spots and black transverse nerves. Two to three lines. This seems to be a rare insect. It has been found in England.

Genus Psila, Meig. Antennæ deflexed, oblique, somewhat remote, the third or terminal joint oblong, compressed, obtuse at the apex, and having a villose dorsal seta at the base; hypostoma reclined, flat, naked, descending: eyes remote, rounded; forehead naked: abdomen six-ringed, the style of the female jointed and acute: wings incumbent, parallel, the first longitudinal nerve simple.

P. *Rosæ.* Shining black, slightly glossed with brassy: head rufous; forehead occasionally with a black longitudinal line; palpi yellow, the apex black: antennæ rufous, the apex blackish, the seta white and pubescent: legs bright yellow; halteres white; wings hyaline. Found in May and September in England and elsewhere. Seven of the thirteen species described by Meigen are natives of Britain.

Genus Loxocera, Meig. Antennæ projecting obliquely, longer than the head, the third or terminal joint very long, linear, compressed, with a villose dorsal seta at the base: hypostoma reclined, flat, naked, descending: eyes distant, rounded: forehead somewhat projecting, naked: abdomen elongate, six-ringed, naked: wings incumbent, parallel; the first longitudinal nerve simple.

L. *ichneumonea.* Hypostoma rufous, the sides with a silvery play of colour; forehead testaceous, with a shining black triangular spot: antennæ half the length of the head, black, the first two joints red: thorax testaceous, the upper part of the neck shining black, the prominences on the shoulders, and two lines on the back, of the same colour; scutellum testaceous; abdomen black and shining; legs and halteres yellow; wings somewhat brownish. Three to four lines. Lat. *Musca ichneumonea*, Linn.; *Musca aristata*, Panz. Found in the southern parts of England, along with two other species, *L. elongata* and *L. sylvatica.*

Genus Chyliza, Fallen. Antennæ deflexed, the third or terminal joint elongate, compressed, obtuse, with a villose dorsal seta at the base: hypostoma perpendicular, flat, without a mystax: eyes distant, oblong, the forehead pubescent: abdomen elongate, pubescent, six-ringed: wings incumbent, parallel, the first longitudinal nerve simple.

C. *atriseta.* Head thick, nearly quadrangular, shining black, with a whitish lustre at the margin of the eyes: antennæ sulphur-yellow, the first joint black, the seta longer than the antennæ, of a deep black, and having a short plume: body shining black; abdomen of the males slightly contracted at the base: legs bright yellow; the apex of the hinder thighs brownish: halteres light yellow: wings greyish, the margin from the middle to the apex brown. Three and a half lines. This insect occurs in Britain, as well as *C. leptogaster.*

Genus Lissa, Meig. Antennæ projecting obliquely, small, the third or terminal joint ovate, compressed, with a villose dorsal seta at the base: hypostoma reclined, somewhat carinated, naked: eyes distant, oblong; the forehead tuberculated anteriorly: abdomen elongate, slender, six-ringed: anterior legs remote: wings incumbent, parallel, the first longitudinal nerve double.

L. *loxocerina.* Hypostoma black, with a silvery-white play of colour: forehead shining black: antennæ with the two first joints small and black, the third reddish yellow; hinder part of the head black, the margin of the eyes white: thorax black, clothed with fine white pubescence: abdomen elongate, cylindrical, black, with a white streak on each side at the incisures; that of the male club-shaped behind, in the female pointed: legs reddish yellow; the anterior pair remote from the hinder; anterior coxæ reddish yellow, thickly clothed with silver-white hairs; hinder coxæ black; the hinder legs longer than the others, and having the tibiæ brown in the middle: halteres yellow: wing-scales wanting. Four lines. Meig. *Zw.* vol. v. pl. lii. fig. 1–4. *Ocyptera dolium*, Fab. Inhabits Britain and some parts of the continent. The generic name is objectionable, as it was previously used by Dr Leach to designate a tribe of crustaceous animals.

Genus Tetanura, Fallen. Antennæ projecting obliquely, the third or terminal joint elliptical, compressed, and obtuse, having a villose seta in the middle of the back: hypostoma perpendicular, carinated, nearly naked: eyes distant, rounded; the forehead flat and setose: abdomen elongate, cylindric, five-ringed: wings incumbent, parallel; the first longitudinal nerve simple.

T. *pallidiventris.* Hypostoma yellow; forehead shining dark brown, yellow in front, and having a spot of yellow on the crown; antennæ yellow: thorax black, bristly, the sides of the breast reddish yellow: scutellum black: abdomen pubescent, black, the first segment and hinder extremity of the terminal one pale yellow: legs rather long, ferruginous; the anterior pair rather remote from the hinder: halteres white, uncovered: wing-scales not visible: wings large, somewhat brownish. Two lines. Found by Professor Fallen at Esperod in Sweden, during the months of July and August. It is the only species of the genus, and has not hitherto been noticed in Britain.

Genus Tanypeza, Fallen. Antennæ somewhat incumbent, approximating, the third joint oblong, compressed, having a naked dorsal seta at the base; hypostoma somewhat reclined, flat, and naked: eyes oblong, remote; the forehead narrow and naked: abdomen elongate, six-ringed: wings incumbent, parallel; the fourth longitudinal nerve recurved.

T. *longimana.* Hypostoma blackish, with a white play of colour; forehead deep black, margined anteriorly with white, and having a white spot on the crown; palpi and antennæ deep black; the proboscis yellow: body shining black: thorax with an oblique slightly interrupted pubescent band, of a changeable white, on the sides: scutellum black and bristly: abdomen in the male with a small projecting piece behind, which bears a two-jointed seta near the apex, and a small protuberance anteriorly; in the female this appendage is short, pointed, and articulated: legs elongate, bright yellow; the first tarsal joint likewise yellow, and as long as the four following, which are brown: halteres white and naked: wing-scales white, so minute as to be scarcely perceptible: wings hyaline. Three lines. Examples of this species are preserved in the collections of Baumhauer and Fallen. We are unacquainted with its native country.

Genus Calobata, Meig. Antennæ incumbent, small, the third joint elliptical, compressed, the base with a dorsal seta, which is shortly plumose or naked: hypostoma flat, naked: eyes rounded; forehead nearly naked: abdomen elongate, cylindric, five-ringed: legs very long and slender; the tarsi short: wings incumbent, parallel.

C. *petronella.* Hypostoma whitish; palpi and antennæ yellow, the last black at the base, and furnished with a scarcely pubescent seta; forehead reddish yellow, margined with white, and having a black spot on the crown: thorax ash grey, with a yellowish callosity on each shoulder: scutellum grey: abdomen black, with whitish incisures; belly dark grey, wrinkled; style of the females rufous anteriorly, the second joint shining rust-brown, carinated: halteres white: wings hyaline: legs ferruginous, the hinder thighs brown at the apex. Three lines. *Musca petronella*, Linn. Found in England, likewise in the neighbourhood of Edinburgh, and other parts of the southern district of Scotland.

Genus Micropeza, Meig. Antennæ projecting, small, the third joint patelliform and compressed, having a long pubescent dorsal seta at the base: head elongate, elliptical; the hypostoma reclined and naked: eyes rounded, somewhat prominent, remote: abdomen elongate, cylindric, six-ringed: legs filiform, very long, the tarsi short; anterior legs remote: wings incumbent, parallel, the length of the abdomen.

M. *corrigiolata.* Hypostoma white; antennæ deep black, with a white seta; forehead black, deepening in the middle: body black: the sides of the thorax without a yellow vitta: abdomen with white incisures: halteres white: wings hyaline: legs yellow, with black tarsi; all the thighs having a black ring before the apex, and the apex itself black; tibiæ behind passing into black. Two lines. The female larger. Meig. *Zw.* v. 384, pl. liii. fig. 6. *Calobata filiformis*, Lat. Rather frequent. We once found it in very great abundance in the month of June, on flowers, by the sides of the Esk, near Dalkeith.

Genus Ulidia, Meig. Antennæ incumbent, small, distant, the third or terminal joint elliptical, compressed, with a naked dorsal seta at the base: hypostoma descending, impressed, naked, the proboscis somewhat prominent: eyes rounded, distant; the forehead broad, rugose, naked: abdomen ovate, depressed, five-ringed; wings incumbent, parallel.

U. *demandata.* Hypostoma fulvous, wrinkled, whitish above; antennæ dark yellow, the third joint with a brown spot anteriorly: forehead shining dark green, somewhat metallic, wrinkled: thorax more or less brassy; abdomen shining black: legs black; the tarsi rufous, with the apex black: wing-scales very small, and, together with the halteres, white: wings clear, with slender nerves. Two lines. *Musca demandata*, Fab. Meig. *Zw.* v. pl. liii. fig. 12. Has been taken near Paris, and in England.

Genus Timia, Meig. Antennæ distant, small, inserted in a foveola, the third joint oval, compressed, with a naked dorsal seta at the base: hypostoma descending, impressed in the middle, naked, the proboscis and palpi somewhat projecting: eyes oblong, distant; forehead villose: abdomen ovate, six-ringed: wings incumbent, parallel.

T. *apicalis.* Head black; forehead wide, and covered with fine pubescence: body shining black, somewhat setaceous, with a small prominence on each shoulder: abdomen finely pubescent: halteres and wing-scales small and white; wings clear, with the base yellowish, and a triangular brown spot at the apex. Three lines. Meig. *Zw.* v. pl. liii. fig. 16. Examples of this insect are preserved in Wiedemann's collection, and others have been obtained from Portugal.

Genus Platysoma, Meig. Antennæ deflexed, short, the terminal joint oblong, prismatic, obtuse, with a naked dorsal seta at the base: hypostoma somewhat descending, impressed, naked, the proboscis and palpi rather projecting; eyes rounded, remote, the forehead nearly naked; abdomen ovate, four-ringed: wings divaricating.

P. *seminationis.* Variegated with ash-grey and black: hypostoma and palpi black; antennæ dark brown: body grey, with black wartz-like points; abdomen pale beneath, the fourth segment as long as the others taken together: legs entirely black: halteres dark brown: wings marbled with fuscous. Two lines. *Musca seminationis*, Fab. Found in the southern parts of Britain, and on the continent.

Genus Piophila, Fallen. Antennæ incumbent, the third joint elliptical, compressed, with a naked dorsal seta at the base: hypostoma subreclined and provided with a mystax: eyes rounded, remote: the forehead broad, glabrous, convex, and setose: abdomen ovate, somewhat setose, glabrous, five-ringed: wings incumbent, parallel, longer than the abdomen.

P. *casei.* Shining black, glabrous: hypostoma and anterior part of the forehead rufous; antennæ rufous, the third joint, with the anterior edge and the apex, more or less black: hinder part of the head black: anterior legs black; base of the thighs and tibiæ rufous, the middle pair of legs entirely rufous; hinder legs rufous, the thighs before the apex with a black ring, more or less wide: anterior coxæ rufous: halteres white: wings hyaline. One

and a half line. *Musca casei*, Linn. Var.; *Tyrophaga casei*, Curtis, *B. E.* vol. iii. fol. 126. Meig. *Zw.* v. pl. liv. fig. 4. The maggot lives in cheese, and leaps.

Genus Homalura, Meig. Antennæ deflexed, distant, the third joint patelliform, compressed, with a naked dorsal seta at the base: hypostoma descending, perpendicular, naked: eyes rounded and remote; the forehead broad, flat, and naked: abdomen ovate, depressed, naked, five-ringed: wings incumbent, parallel, the length of the abdomen.

H. *tarsata*. Body shining black, everywhere thickly covered with tubercular dots: thorax without a distinct cross suture: legs black, with yellow tarsi: stalk of the halteres black, the head globose and white. One and a half line. Meig. *Zw.* v. pl. liv. figs. 8 and 9. Inhabits Austria and England.

Genus Thyreophora, Lat. Antennæ very minute, inserted in a foveola, the terminal joint lenticular, and having a naked dorsal seta at the base: hypostoma descending, reclined, and having a mystax: eyes small and round; the forehead broad, rather prominent, convex, and villose: abdomen oblong, six-ringed: wings incumbent, parallel, longer than the abdomen.

T. *cynophila*. Head bright orange yellow; forehead pubescent, with two black spots: body dark steel blue, shining, everywhere beset with long black hairs: scutellum of the male nearly half the length of the abdomen, truncated at the apex, and bearing a strong seta at each side; that of the female small and triangular: legs dark steel blue, pubescent, the four anterior tarsal joints rufous at the base: wing-scales blackish: halteres white: wings hyaline, with two black dots on each. Four lines. Meig. *Zw.* v. pl. liv. figs. 10, 15. Has occurred in France.

Genus Actora, Meig. Antennæ small, distant, the third joint sub-globose, with a naked dorsal seta at the base: hypostoma perpendicular, descending, pubescent, without a mystax: eyes rounded, distant; the forehead broad, flat, villose: abdomen elongate, six-ringed: wings longer than the abdomen.

A. *æstuum*. Hypostoma white; forehead ferruginous and pubescent; antennæ dark brown: thorax light brown, finely pubescent, with small black dots; sides light grey, with a brownish spot before the base of the wings: scutellum semicircular, light brown: abdomen cinereous: legs dark grey, with rufescent tarsi; in the males the anterior tibiæ and tarsi are thickly covered beneath with shining whitish-yellow hair: wing-scales small and white: halteres white: wings hyaline. Four lines. Meig. *Zw.* v. pl. liv. figs. 19, 20. This insect has been taken in England by Dr Leach.

Genus Lipara, Meig. Antennæ distant, small, the terminal joint lenticular, with a naked dorsal seta: hypostoma descending, pubescent, the forehead broad, rather prominent, and pubescent: eyes rounded, small: abdômen elliptical, pubescent, five-ringed.

L. *lucens*. Head nearly round, finely pubescent; antennæ brown: thorax finely pubescent, brownish grey; when seen in certain directions four dark-brown lines are perceptible, the two central ones abbreviated: abdomen oval, pubescent, the colour of the thorax: halteres brown: wing-scales wanting: thighs dark brown: tibiæ and tarsi yellow: wings yellowish brown. Three lines. Inhabits Germany.

Genus Lucina, Meig. Antennæ distant, the third joint ovate, compressed, with a naked dorsal seta at the base: hypostoma descending, naked, and impressed; the forehead broad, somewhat prominent, slightly pubescent, the vertex setose: eyes rounded, small; abdomen flat, oblong, six-ringed: wings longer than the abdomen.

L. *fasciata*. Hypostoma pearly grey, with a silky gloss; forehead ferruginous; antennæ brown: thorax grey, with brownish longitudinal lines, and black spots and bristles; scutellum grey with a black spot: abdomen grey, with a black band on each segment from the second to the fifth, which is widened anteriorly in the middle, and on the second segment there is a longitudinal streak of white: legs reddish grey, the thighs spotted with black: wings somewhat greyish, with two black spots. Three and a half lines. Germany; Marseilles.

Genus Eurina, Meig. Antennæ distant, short, the third joint ovate, compressed, with a naked dorsal seta: head trigonate, pubescent, hypostoma reclined; forehead broad, flat, rather prominent: eyes small and rounded: abdomen oblong, six-ringed; wings incumbent, longer than the abdomen.

E. *lurida*. Forehead ferruginous; hypostoma whitish; antennæ ferruginous at the base, the third joint entirely brown on the outside, the inside yellow with a brown apex: thorax and scutellum dark brown with deep punctures; abdomen and also the legs ferruginous: halteres white: wings somewhat clouded with brown. Two lines. Examples of this insect are preserved in Baumhauer's collection. Its native country is unknown.

Genus Orygma, Meig. Antennæ small, distant, deflexed, the terminal joint ovate, compressed, with a naked dorsal seta at the base: hypostoma reclined, naked: the forehead broad, flat, and setose: eyes rounded, small: abdomen elliptical, villose, six-ringed: legs strong.

O. *luctuosa*. Forehead black and bristly; hypostoma shining ferruginous, the antennæ of a similar colour: thorax flat and bristly: abdomen elliptical, covered with strong hairs; legs ferruginous and pubescent: halteres uncovered, the wings somewhat brownish. Three lines. Meig. *Zw.* vi. pl. lv. fig. 17. Taken by Dr Leach in the neighbourhood of London.

Genus Camarota, Meig. Antennæ porrect, small, the third joint oblong, obtuse, with a thick villose dorsal seta at the base: hypostoma reclined, naked: forehead wide, flat, somewhat arched anteriorly, pubescent: eyes transversely elliptical: wings incumbent, arched.

C. *flavitarsis*. Hypostoma white; forehead ferruginous and finely pubescent; antennæ black: thorax metallic black, covered with small depressions, and marked with two longitudinal furrows behind: abdomen black: legs of a similar colour, the apex of the tibiæ and the tarsi yellow: halteres dark brown, uncovered: wings brownish grey. Found in Germany, at Paris, and near Marseilles.

Genus Cœlopa, Meig. Antennæ small, the terminal joint small and rounded, with a naked dorsal seta at the base: hypostoma excised, villose, the mouth rather prominent; forehead flat, wide, setose: eyes somewhat rounded: abdomen oblong, setose, five-ringed: wings incumbent, longer than the abdomen.

C. *frigida*. Hypostoma thickly covered with hair, the forehead black and thickly covered with bristles; antennæ ferruginous: thorax bristly, and of a black colour: abdomen black, that of the male thickly pubescent and truncated, that of the female pointed and bristly: halteres white, uncovered; wings somewhat greyish: legs reddish brown, thickly covered with hair. Two lines. *Musca frigida*, Fab. This insect is found in Lapland and the most northern countries of Europe.

Genus Sciomyza, Meig. Antennæ somewhat distant, small, obliquely deflexed, the third joint oblong, obtuse, with a dorsal seta at the base, which is either plumose, or pilose, or naked: hypostoma descending or reclined, the forehead broad, setose, or villose: eyes rounded: abdomen oblong, flat, shortly setose, five-ringed: wings incumbent, longer than the abdomen.

S. *simplex*. Shining ferruginous, except the thorax and

the last four joints of the tarsi, which are dark brown: the abdomen is marked with a brown longitudinal line: halteres white, the wings somewhat brownish. Three lines. This genus contains twenty-nine species, none of which have been yet detected in Britain.

GENUS DACUS, Meig. Antennæ deflexed obliquely, as long as the hypostoma, the third or terminal joint narrow, elongate, obtuse, compressed, with a naked dorsal seta at the base: hypostoma perpendicular, naked, the forehead broad, somewhat setose: abdomen naked, four-ringed.

D. *Oleæ.* Antennæ ferruginous: thorax cinereous on the back, with three longitudinal lines of black, the sides ferruginous anteriorly, black behind; the shoulders, a small spot at the base of the wings, and another of an elliptical form beneath them, sulphur-yellow; the scutellum of the same colour: abdomen rufous, with three interrupted black bands: legs rufous: halteres white: wings hyaline, having a dark-brown spot at the apex. Two lines. Inhabits Germany, France, and Italy.

GENUS PLATYCEPHALA, Meig. Antennæ projecting obliquely, rather remote, the two terminal joints equal, the third with a naked dorsal seta at the base: hypostoma reclined, naked, the forehead flat, broad, naked: eyes rounded: wings incumbent, longer than the abdomen, the transverse nerves approximating on the disc.

P. *umbraculata.* Forehead ferruginous, with a black impression in the middle; hypostoma likewise ferruginous; antennæ with the first and second joints black, the third ferruginous, the apex black and the seta white: thorax ferruginous, marked with three broad vittæ of a dark-brown colour on the upper side: abdomen wholly dark brown, ferruginous on the under side: legs ferruginous: wings greyish. Two lines. *Musca umbraculata*, Fab. Only three species have been described as pertaining to this genus. The one described above, and *P. planifrons*, have been found in Britain. *P. nigra* occurs in Germany and France.

GENUS SEPEDON, Lat. Antennæ porrect, longer than the head, the second joint elongate, compressed, setose; third acute, emarginate above, and having a naked dorsal seta at the base: hypostoma perpendicular, descending, naked, the forehead broad and somewhat prominent: eyes rounded and rather prominent: abdomen elongate, five-ringed, naked: hinder thighs thick and spinose beneath: wings incumbent.

S. *sphegeus.* Shining bluish black; antennæ dark brown, the seta black above, white beneath; eyes green, with a dark purple fascia: thorax cinereous, with two dark lines along the back; the sides shining metallic black: halteres white: wings brownish yellow, unspotted; legs bright ferruginous. Three lines. *Sepedon palustris*, Lat. Found during the summer in various parts of the continent, and in England, but is nowhere common.

GENUS DORYCERA, Hoff. Antennæ remote, the length of the head, the second and third joints equal in length, second linear, compressed, and setose; third conical, ventricose at the base, and furnished with a naked seta on the back: hypostoma reclined, arched, and naked; forehead flat, somewhat prominent, villose, and flat: eyes rounded and a little prominent: abdomen oblong, five-ringed, the style of the female jointed: wings incumbent, longer than the abdomen.

D. *graminum.* Hypostoma shining ferruginous, spotted with black; forehead ferruginous, with two black lines and a white ring round the eyes: antennæ ferruginous, black at the apex: thorax grey, with six black lines; scutellum grey, spotted with black on the sides: abdomen blackish, inclining to reddish brown in the female, and having a pale interrupted line on the back: legs ferruginous, with brown tarsi: halteres bright yellow: wings greyish. Four lines. *Musca graminum*, Fab.; *Tetanocera graminum*, Lat. Inhabits France; apparently not found in Britain.

GENUS TETANOCERA, Dum. Antennæ porrect, remote, the second joint compressed and setose, third excised on the upper side, compressed, with a plumose or naked dorsal seta: hypostoma descending (rarely reclined) furrowed, naked; the forehead broad and setose: eyes rounded and somewhat prominent: abdomen oblong, five-ringed, somewhat setose: wings incumbent, projecting beyond the abdomen.

T. *Hieracii.* Hypostoma and palpi white; forehead ferruginous, without impressions, with brown spots on the crown, and four black points at the margin of the eyes: antennæ rufous: thorax bright yellow, finely shagreened, and covered with black spots: scutellum yellow, with a black spot: abdomen bluish grey, with three confluent deep-black spots on each segment: legs bright yellow, the apex of the hinder thighs spotted with black: halteres white; wings white, variegated with dark brown. Two lines. *Tephritis Hieracii*, Fab.; Meig. *Zw.* vi. pl. lvii. fig. 18. Not unfrequent in summer among grass. It is found in Britain, along with eleven other species.

GENUS HETEROMYZA, Meig. Antennæ porrect, somewhat remote, the third joint orbicular, compressed, with a naked dorsal seta: hypostoma descending, perpendicular, furnished with a mystax: forehead broad and setose: eyes rounded: abdomen oblong, five-ringed: wings longer than the abdomen, the rib without bristles.

H. *atricornis.* Hypostoma white, with a longitudinal furrow on each side: forehead rufous, having a white ring round the eyes; the crown and hinder part of the head bluish grey; palpi rufous: antennæ deep black, furnished with a long seta: thorax and scutellum bluish grey: abdomen and legs rufous. Three lines. Meig. *Zw.* vi. pl. lvii. fig. 21. Meigen describes four species of Heteromyzæ, of which the only one hitherto detected in England is *H. buccata*, Fallen. No locality is cited for *H. atricornis*.

GENUS HELOMYZA, Meig. Antennæ somewhat deflexed, remote, the third joint oblong or orbicular, having a plumose or naked dorsal seta at the base: hypostoma perpendicular, descending, furnished with a mystax; forehead wide and setose: eyes rounded: abdomen oblong, six-ringed: wings incumbent; the costa setose.

H. *rufa.* The male is ferruginous, with black bristles; the third joint of the antennæ is elliptical, and bears a long plumose seta: abdomen with black bands, which are widened in the middle: hinder knees and two last joints of the tarsi black: wings somewhat brownish, with two white marginal spots at the apex. This species has been found in England by Dr Leach. *H. ustulata*, figured by Curtis (*B. E.* fol. 66), and by Meig. (*Zw.* pl. lvii. fig. 30), is also a native of Britain.

GENUS DICHÆTA, Meig. Antennæ distant, somewhat deflexed, short, the third or terminal joint oblong, compressed, having a pectinated dorsal seta at the base: hypostoma somewhat descending, convex, setose; the forehead wide, setose: eyes rounded: abdomen ovate, five-ringed, that of the male with long setæ at the apex: wings incumbent; the transverse nerves remote.

D. *caudata.* Hypostoma brownish yellow; forehead dark grey; two lower joints of the antennæ brown, the third bright yellow: body dark grey, somewhat bristly; thorax with three broad lines of black: legs dark grey, the tarsi yellow: halteres white: wings greyish. Two lines. A rare insect on the continent. According to Curtis, it has occurred in Britain.

GENUS NOTIPHILA, Meig. Antennæ somewhat remote, deflexed, short, the third joint oblong or orbicular,

compressed, with a pectinated dorsal seta at the base; hypostoma somewhat descending, rather naked, convex; the forehead broad, setose: eyes rounded: abdomen rather flat, ovate or oblong, five-ringed: wings incumbent, longer than the abdomen; the transverse nerves remote.

N. *cinerea.* Hypostoma fulvous, without lustre, furnished with short bristles on each side of the eyes, which are surrounded with a whitish ring: forehead, thorax, and scutellum ferruginous; on the thorax there are six rows of small tubercles of a black colour: antennæ brown, the third joint yellow at the base: abdomen cinereous, with three black spots on both sides: legs ferruginous, with black thighs: halteres white: wings nearly hyaline. One line and a half. During spring and summer very common in some countries on the *Equisetum palustre.* It occurs in Britain, but does not seem common.

Genus Discomyza, Meig. Antennæ deflexed, short, third joint oblong, compressed, obtuse, with a pectinated dorsal seta at the base: hypostoma short and rugose; forehead broad, short, and naked: eyes oblong: abdomen depressed, suborbicular, naked, four-ringed: wings deflexed, the length of the abdomen.

D. *incurva.* Black and glossy, the tarsi yellow: halteres small and white: wings somewhat greyish, the anterior margin brown. One line and a half. Meig. *Zw.* vi. pl. lviii. fig. 16, 17. Inhabits Austria and other parts of the continent.

Genus Ochthera, Lat. Antennæ incumbent, short, the third joint elliptical, compressed, with a pectinated dorsal seta at the base: hypostoma descending, naked, convex, coarctate at the apex; forehead broad, impressed, naked: eyes rounded and somewhat prominent: abdomen flat, elliptical, naked, five-ringed: anterior thighs swollen, and spinose beneath: wings incumbent, the fourth longitudinal nerve recurved at the apex.

O. *Mantis.* Hypostoma brownish, with a white play of colour; forehead black: body naked, black, with a metallic lustre, the thorax marked with three black lines; abdomen with a small white spot on each side of the second, third, and fourth incisures: legs black: halteres white: wings somewhat cinereous. Two lines. *Musca manicata,* Fab. Found in August and September.

Genus Stegana, Meig. Antennæ incumbent, the third joint oblong, obtuse, compressed, with an irregularly plumose dorsal seta at the base: hypostoma somewhat impressed, and furnished with a mystax; forehead broad and setose: eyes oblong: abdomen oblong, six-ringed: wings longer than the abdomen, incurved, deflexed.

S. *nigra.* Hypostoma and forehead ferruginous, the latter bristly; antennæ yellow: body shining black, somewhat bristly; legs yellow, the hinder thighs brownish: halteres yellow: wings smoke colour. One line and a fourth. Meig. *Zw.* vi. pl. lviii. figs. 24, 25. *Drosophila curvipennis,* Fallen. A scarce insect on the continent, and not occurring at all in Britain.

Genus Drosophila, Meig. Antennæ incumbent, the third joint oblong, obtuse, compressed, with an irregularly plumose dorsal seta at the base: hypostoma with a mystax, the forehead broad and setose; eyes rounded: abdomen oblong, six-ringed: wings incumbent, longer than the abdomen.

D. *funebris.* Hypostoma and forehead rust-brown: antennæ dark brown, the base yellow: thorax shining testaceous: abdomen shining black, each of the incisures behind with a rather broad yellow band: legs ferruginous: wings rather obscured with brown, but not spotted. One line and a half. *Musca funebris,* Gmel.; *Musca cellaris,* Linn. Found during spring and summer occasionally.

Genus Asteia, Meig. Antennæ deflexed, the terminal joint patelliform, with an irregularly pectinated dorsal seta at the base: hypostoma naked; the forehead broad, and somewhat setose: eyes rounded (fasciated): abdomen naked, five-ringed: wings incumbent, large; the ordinary transverse nerve wanting.

A. *concinna.* Straw colour, the hypostoma with two black spots, and two black longitudinal streaks on the crown: thorax shining black, pale round the outer side, the sides and breast straw-colour: scutellum straw-colour, with a black spot at the base; abdomen and legs entirely straw-colour; wings large and hyaline. One line. Both this and the only other species of the genus, *A. amœna,* occur in England.

Genus Ochthiphila, Meig. Antennæ deflexed, the terminal joint oblong, compressed, obtuse, with a naked dorsal seta at the base: hypostoma nearly naked; the forehead broad and setose: eyes rounded: abdomen oblong, five-ringed: wings incumbent.

O. *Juncorum.* Light cinereous: antennæ yellow, with the apex black; the abdomen with two rows of black spots: thighs grey; the apex, tibiæ, and first joint of the tarsi bright yellow, the four other joints brown: wings hyaline. One line. Meig. *Zw.* vi. pl. lix. fig. 11. Common in Germany. None of the species, which are seven in number, have been detected in Britain.

Genus Diastata, Meig. Antennæ incumbent, the terminal joint compressed and obtuse; have a dorsal seta at the base, which is densely plumose or naked: hypostoma with a mystax: the forehead broad and setose: eyes somewhat rounded: abdomen oblong, five-ringed: wings incumbent, longer than the abdomen, the transverse nerves remote.

D. *obscurella.* Hypostoma whitish; antennæ and forehead rufous, the margin of the eyes and the crown light grey; the third joint of the antennæ brown at the apex: thorax cinereous: abdomen black, with some lustre: legs rufous: halteres white. One line. Meig. *Zw.* pl. lix. fig. 15. Rather scarce: not indigenous to this country.

Genus Opomyza, Meig. Antennæ deflexed, the terminal joint ovate and compressed, having a dorsal seta at the base, which is shortly plumose or pubescent: hypostoma naked, or furnished with an imperfect mystax; the forehead broad and setose: eyes rounded: abdomen elongate, six-ringed: wings incumbent.

O. *combinata.* Palpi and proboscis white; head, antennæ, thorax, and legs rather bright shining rufous: abdomen of the males linear, shining black, rufous at the base; that of the female more elliptical, flat, rufous, with black bands at the incisures: halteres white: wings small, hyaline, the cross nerves and a spot at the apex dark brown. One line and a third. *Tephritis combinata,* Fab. Inhabits Britain and Germany.

Genus Ephydra, Fallen. Antennæ deflexed, the terminal joint oblong, compressed, and obtuse, with a naked dorsal seta at the base: hypostoma arched or convex, villose; the forehead broad and setose: eyes rounded, somewhat prominent: abdomen elliptical, depressed: wings incumbent, longer than the abdomen.

E. *palustris.* Hypostoma brownish black, setaceous, at least about the mouth; forehead dark green, shining: antennæ black, with a rather thick seta: body shining dark green: scutellum arched: halteres white: wings pale brown: legs black. One line. Found in marshy places.

Genus Heteroneura, Meig. Antennæ porrect, the second joint the same length as the third, the latter orbiculate, with a pubescent seta inserted in the middle of the back; forehead flat, furnished with a mystax; the forehead broad and setose: eyes rounded: abdomen elongate, five-ringed; wings incumbent, the transverse nerves approximating in the middle of the disc.

H. *nubila.* Hypostoma and forehead ferruginous, with a whitish lustre round the margin of the eyes; antennæ ferruginous, the third joint somewhat brownish: thorax shining ferruginous, passing into brown, with four dark-brown lines on the back, and a white one on the sides, reaching to the base of the wings; the sides ferruginous: abdomen black: legs rufescent: halteres white: wings somewhat greyish. Male one and a half, female nearly two lines. Inhabits Austria and other European countries.

Genus Gitona, Meig. Antennæ incumbent, the terminal joint elliptical, compressed, having a naked dorsal seta at the base: hypostoma carinated in the middle, and provided with a mystax; the forehead broad and setose: eyes rounded: abdomen ovate, flat, five-ringed: wings incumbent, longer than the abdomen; the transverse nerves approximating.

G. *distigma.* Hypostoma, palpi, and antennæ rufous; forehead of a similar colour, with two brown lines; thorax setaceous, light grey, with three dark somewhat undulating lines: scutellum light grey or yellowish: abdomen shining rufous, with four bands and a dorsal line of black: legs and halteres rufous; wings hyaline. Two lines. Meig. *Zw.* vi. pl. lx. fig. 19. Found in the south of France, and elsewhere.

Genus Milichia, Meig. Antennæ porrect, the terminal joint patelliform, with a naked dorsal seta at the base; hypostoma impressed, and provided with a mystax; the forehead broad and setose; eyes rounded: abdomen ovate, four-ringed: wings incumbent, longer than the abdomen.

M. *speciosa.* Male. Hypostoma white, setaceous about the mouth and sides; palpi black and pubescent; forehead slate-grey with a white play of colour, and when seen in some directions two brownish lines are perceptible: antennæ black: thorax greyish white: scutellum black: abdomen shining silver-white; the belly, halteres, and legs, black: wings hyaline, the anterior edge brown from the middle to the apex. Two lines. Meig. *Zw.* pl. lx. fig. 23. Has been taken near Marseilles, and in Provence.

Genus Leucopis, Meig. Antennæ porrect, the third joint patelliform, with a naked dorsal seta at the base: hypostoma somewhat impressed, naked; the forehead broad and naked: eyes rounded: abdomen ovate, five-ringed, depressed: wings incumbent, longer than the abdomen.

L. *griseola.* White with a bluish tinge; antennæ deep black: thorax with four pale-brown lines, the central one narrowest: abdomen with a black play of colour at the base, and marked with two black dots: halteres white: wings hyaline, with brown nerves: thighs grey, the apex yellow; the tibiæ and tarsi rufous, the former encircled with a pale-brown ring. One line. *Anthomyza griseola*, Fallen; Meig. *Zw.* vi. pl. lx. fig. 28. Found on the continent, but the special localities are not mentioned.

Genus Gymnopa, Meig. Antennæ incumbent, the third or terminal joint somewhat oblong, compressed, and obtuse, with a naked dorsal seta at the base: hypostoma descending, naked, tuberculated; the forehead broad, and nearly naked: eyes rounded: abdomen ovate, glabrous, five-ringed: wings incumbent, longer than the abdomen; the fifth longitudinal nerve abbreviated behind.

G. *subsultans.* Dark metallic green, shining: head and legs black: halteres white. One line and a half. *Syrphus subsultans*, Fab. Found in August and September. The genus contains four species, none of which have been hitherto noticed in Britain.

Genus Chlorops, Meig. Antennæ deflexed, porrect, the terminal joint patelliform, with a naked or pubescent dorsal seta at the base: hypostoma descending, naked; forehead broad and pubescent: eyes rounded: abdomen elliptical, naked, five-ringed: legs simple: wings incumbent, the transverse nerves approximating on the disc.

C. *gracilis.* Straw-colour, as well as the antennæ and legs: forehead rufous: thorax marked with three dark-grey lines, of which the central one is abbreviated behind, and the others in front; and on each side of the breast there is a black spot; there is also a black spot on each side of the first incisure of the abdomen. Three lines. *Meig. Zw.* vi. pl. lxi. fig. 17. Has been taken near Paris on the flowers of *Chrysanthemum leucanthemum*, in Russia, and in Austria. The genus is composed of sixty species, all of them minute insects; and a considerable number appear to inhabit Britain.

Genus Meromyza, Meig. Antennæ deflexed, porrect, the third or terminal joint nearly patelliform, with a naked dorsal seta at the base; hypostoma descending, naked; the forehead broad, rather prominent and pubescent; eyes rounded and somewhat prominent: abdomen conical, naked, five-ringed: hinder thighs thickened: wings incumbent, the transverse nerves approximating in the middle of the disc.

M. *pratorum.* Pale-greenish yellow, as well as the antennæ and legs; hinder part of the head unspotted: thorax with three greenish-grey lines, the central one running along the scutellum also; abdomen, with an interrupted dorsal line of black, and a black spot on each side at the base. Two lines. Meig. *Zw.* vi. pl. lxi. fig. 25. Inhabits Germany and Britain.

Genus Agromyza, Fallen. Antennæ deflexed and porrect, the third joint orbicular, with a naked dorsal seta at the base: hypostoma with a mystax; the forehead broad and setose: eyes rounded: abdomen five-ringed: wings incumbent, longer than the abdomen, the transverse nerves approximating.

A. *denticornis.* Head yellow, with a black point on the crown; antennæ black, with a yellow base; the third joint having a small horn before the apex: thorax with a yellow streak on the sides: scutellum yellow: halteres white: legs black, with yellow thighs. One line. Meig. *Zw.* vi. pl. lxi. figs. 33, 34. *Chlorops denticornis*, Panzer; *Chlorops Meigenii*, Fallen. Found in England and on the continent. The genus is extensive, comprehending sixty-nine species. Few of these have been detected in this country, although there can be little doubt that a large proportion inhabit Britain.

Genus Phytomyza, Fallen. Antennæ porrect, the terminal joint patelliform, with a naked dorsal seta: hypostoma with a mystax; forehead broad and setose: eyes rounded: abdomen elongate, six-ringed: wings incumbent, longer than the abdomen, the transverse nerves placed at the base of the wings, the ordinary one generally wanting.

P. *flavicornis.* Blackish; thorax and scutellum dark grey; antennæ entirely yellow: halteres white: wings somewhat grey: the incisures of the abdomen and the legs yellow. Two thirds of a line. Meig. *Zw.* vi. pl. lxii. fig. 6. Found on the continent, but is not common.

Genus Therina, Meig. Antennæ porrect, the third joint patelliform, with a long naked dorsal seta at the base: hypostoma impressed, and furnished with a mystax; the forehead broad and pilose: eyes rounded: abdomen oblong, five-ringed: wings incumbent, the transverse nerves remote.

T. *femoralis.* Hypostoma ferruginous, forehead of the same colour anteriorly, grey behind; antennæ black: thorax dark grey, with four rather indistinct dark lines: abdomen black: halteres white: wings hyaline: legs ferruginous; the anterior thighs thickened. Scarcely one line. Found on the continent.

Genus Borborus, Meig. Antennæ porrect, the terminal joint spheroidal, with a naked dorsal seta: hypostoma impressed, and furnished with a mystax; forehead broad, setose, declined: eyes rounded: abdomen flat, five-ringed: hinder metatarsi abbreviated and thickened: wings incumbent, longer than the abdomen (or wanting).

B. *clunipes.* Hypostoma and anterior part of the forehead testaceous: body dark brown: scutellum elongate, flat, setaceous: halteres brown: wings hyaline: the two first joints of the hinder tarsi thickened, the second somewhat longer than the first. One half line. Found in dung; but is rare. It occurs in England.

FAMILY XXIV.—TRINEURÆ.

Genus Phora, Lat. (Plate CCLI. figure 30.) Antennæ inserted at the opening of the mouth, globose, with an elongate erect naked seta; palpi exserted, clavate, setose: abdomen six-ringed: hinder legs elongate: wings incumbent.

P. *incrassata.* Black, the forehead tuberculated: palpi and antennæ black: the first incisure of the abdomen margined with white: legs black, the anterior pair with the apex of the thighs, the tibiæ, and tarsi, ferruginous: halteres brown: wings nearly hyaline, somewhat brownish. One and a half line. In September; not rare.

Genus Conicera, Meig. Antennæ erect, conical, with a naked terminal seta: palpi exserted, setose: abdomen six-ringed: wings incumbent.

C. *atra.* Velvet black; forehead pitch-brown; anterior tibiæ and tarsi rufous; wings clear hyaline. Half a line. Found in September; but nowhere common. Apparently not indigenous to Britain.

DIVISION II.—EPROBOSCIDEÆ.[1]

FAMILY CORIACEÆ.

Genus Hippobosca, Linn. (Plate CCLI. figures 31 and 31 *a.*) Antennæ gemmiform, inserted into the sides of the hypostoma, and having a naked apical seta: ocelli wanting: the tarsi with equal bidentate claws: wings parallel, incumbent, obtuse, with many nerves.

H. *equina.* Forehead and hypostoma shining ferruginous: eyes pitch-brown: thorax shining dark brown, the shoulders ferruginous; before the scutellum there are three yellow spots, of which the central one forms an acute triangle: scutellum yellow, with black spots on the sides: abdomen pubescent, brownish grey: legs ferruginous, the thighs and tibiæ of the middle pair with a dark ring, the hinder pair with two: halteres black: wings brownish, the marginal nerves dark brown. Four lines. Linn. Fab. On horses and cattle.

We are still indebted to Réaumur for the greater part of our knowledge regarding the very singular mode of production in the genus Hippobosca, or forest-flies, as these insects are sometimes called. That delightful observer has named them *Mouches Araignées.* The larva is hatched and nourished within the body of the mother, and remains there till after its transformation to the nympha state. Hence the term *pupiparous,* as applied to the Hippoboscæ and other genera of the tribe. The nymph, or rather cocoon, is at first of a milky whiteness, with a large plate (plaque) at one end, black and shining, like ebony. It is of a round and flattened form, emarginate at the plated end, where it forms two rounded or horn-like eminences. It becomes entirely black soon after exclusion, and the skin or covering, of a cartilaginous or scaly texture, resists a strong pressure of the fingers, and is even difficult to cut with the sharpest scissors. The body of the mother scarcely equals the dimensions of the nymph, and it has often been a subject of marvel how the greater should proceed from the less. It appears, however, that the cocoon is possessed of an expansive power, which is probably exercised the moment after its exclusion from the body of the parent. The hardness and solidity of the skin, though well qualified to defend the nymph from injury, might seem to present a serious obstacle to the escape of the perfect insect. But nature, so complete and bountiful in all her doings, and so pervaded even in her minutest operations by the perfect wisdom of her great Author, has provided against this seeming inconvenience by a beautiful contrivance. When we examine the larger end by means of a microscope, we shall perceive the feeble trace of what in fact constitutes a kind of cap or cowl, and which may sometimes be made to spring off even by the touch of a penknife. When the perfect insect is ready for exclusion, it finds it an easy matter to manage this piece of natural mechanism. The coriaceous envelope to which we have alluded is, in fact, the distended and somewhat altered skin of the larva, and within it Réaumur succeeded in detecting the exuviæ of the nymph. The phenomena of transformation are, therefore, so far analogous to what we observe in the coarctate pupæ of some other dipterous tribes, and the chief anomaly consists in the larva passing the entire period of its exis-

[1] In our copy of Meigen's *European Diptera*, the work by which we have been guided in the systematic portion of our exposition of the order, there is (at page xxxiii. of the first volume) a brief exposition of the characters of Division I. Proboscideæ. This we have given at page 258 of the present treatise. In the sixth and last volume of the German author we do not, however, find any indication of Division II. Presuming, nevertheless, from the strong disparity of character presented by the Coriaceæ, when compared with the preceding families, that they must constitute the other principal branch of the dipterous order, we have applied the name of Eproboscideæ, as significative of the division sought for. It was so applied by Latreille (*Gen. Crust. et Insect.* t. iv. p. 360), as well as (excepting *Nycteribia*) by Dr Leach (*Wernerian Memoirs*, vol. ii. p. 547), to the family in question. The species of which it is composed are in truth of a very singular structure and economy, and altogether of a nature so anomalous, as to cause some doubts as to their proper position in the system. They are now regarded as constituting a separate order, under the name of Homoloptera, by Leach, Macleay, Stephens, and other English naturalists, and form the family Pupipara of Latreille. Some contrariety of opinion still exists regarding the structure of the mouth. We shall here satisfy ourselves by a quotation from the last-named entomologist, to whom we have been already so deeply indebted. "La tête de ces insectes, vue en dessus, est divisée en deux aires ou parties distinctes, dont l'une postérieure et principale, ou composant plus spécialement la tête, porte les yeux, et reçoit, dans une échancrure antérieure, l'autre partie. Celle-ci se partage aussi en deux, dont la postérieure plus grande et coriace porte latéralement les antennes, et dont l'autre constitue l'appareil manducateur. La cavité inférieure et buccale de la tête est occupée par une membrane; on voit sortir de son extrémité un suçoir, naissant d'un petit bulbe ou pédicule avancé, composé de deux filets ou soies très rapprochés, et recouvert par deux lames coriaces, étroites, alongées et velues, qui lui font l'office de gaîne. Que ces lames ou valvules représentent, ainsi que je l'ai présumé, les palpes des autres diptères, ou qu'elles soient les pièces d'une gaîne proprement dite, comme le pense M. Dufour, à l'occasion d'une espèce d'ornithomyie (*Annales des Scienc. Nat.* x. 243, xi. 1), où il a decouvert deux petits corps, qu'il prend pour des palpes, il n'en serait pas moins vrai, que la trompe de ces insectes différerait sensiblement de celle des diptères précédents, et que la gaîne, dans ce cas, aurait plus de rapports avec celle de la trompe de la puce, dont elle s'éloignerait cependant par l'absence d'articulations. (*Règne Animal*, t. v. p. 538.)

Diptera Eproboscideæ.

tence within the body of the mother, and being *born* in the pupa state.[1]

Genus Ornithobia, Meig. Antennæ small, immersed, inserted on the sides of the hypostoma, papillary, naked: ocelli wanting: tarsi with unequal bidentate claws: wings parallel, incumbent, with three nerves.

O. *pallida*. The colour of the head is ferruginous; the proboscis of a similar colour, shorter than the head: thorax flat, rounded, shining black, with a rather large ferruginous spot on each shoulder, and two lines of the same colour in the middle; the hinder part setaceous, at least on the sides; scutellum transverse, ferruginous, the hinder margin bristly: halteres white: abdomen ferruginous, oval, pubescent: wings nearly hyaline, with pale nerves: legs ferruginous, pubescent, robust: the first four joints of the tarsi very short, the fifth longer, with two long unequal claws, the outer claw shorter than the interior one. Two lines. Rare; apparently not found in Britain.

Genus Ornithomyia, Lat. Antennæ gemmiform, setose, inserted into the sides of the hypostoma; vertex with three ocelli; tarsi with tridentate claws: wings incumbent, obtuse.

O. *avicularia*. Greenish yellow: antennæ and proboscis ferruginous; eyes pitch-brown: thorax blackish on the sides, with a yellowish longitudinal line: wings smoke colour with dark-brown nerves, the longitudinal nerves not very distinct: legs pubescent. Two to two and a half lines. *Hippobosca avicularia*, Linn. Degeer, vi. 114, pl. xvii. fig. 21–27. These insects occur on different species of birds, but never on quadrupeds,—a fact in their history which, in connection with the difference of structure, renders their generic separation from Hippobosca the more advisable. Latreille thinks that their metamorphoses resemble those of the last-named genus. The species above described is extremely vivacious, runs swiftly, sometimes side foremost like a crab, and flies with considerable facility.

Genus Stenopteryx, Meig. Antennæ gemmiform, setose, inserted into the sides of the hypostoma: vertex with three ocelli: tarsi with tridentate claws: wings very narrow, acute, longer than the abdomen.

S. *hirundinis*. This species is very closely connected with those of the preceding genus, differing chiefly in the long, narrow, pointed wings: the colour is ferruginous, with pitch-brown eyes: the antennæ are covered with long black setæ. Two lines. *Hippobosca hirundinis*, Linn.; *Stenepteryx hirundinis*, Leach; *Ornithomyia hirundinis*, Lat. Meig. *Zw.* vi. lxiv. fig. 5. Found on different kinds of swallows, especially the *Hirundo Apus* of Linn. The wings of this species are not well adapted for flight. Réaumur once found as many as thirty in a swallow's nest.

Genus Anapera. Antennæ gemmiform, setose, inserted into the sides of the hypostoma: ocelli wanting: tarsi with tridentate claws: wings short and acuminated.

A. *pallida*. Ferruginous; the abdomen brown: antennæ with numerous long black hairs: thorax rhomboidal, the anterior part embracing the head on both sides; sinuated on each side, but widened in the middle, and the back impressed with a deep longitudinal line: the hinder part setaceous, especially towards the sides: scutellum transverse: legs robust, especially the thighs, and covered with long hair: wings short, scarcely longer than the abdomen, somewhat greyish, with ferruginous nerves, the apex acute. Two and a half lines. *Ocypterum pallidum*, Leach; *Mouche-araignée*, Geoff. *Ins.* ii. 547, 2. Found on swallows, especially the swift.

Genus Nycteribia.

Genus Melophagus, Lat. Antennæ papillary, immersed, inserted in the sides of the hypostoma: eyes linear and small: ocelli wanting: tarsi with bidentate claws: wings wanting.

M. *ovinus*. Ferruginous; the abdomen brown; forehead wide, with the crown smooth and without ocelli, the other parts setaceous: proboscis as long as the head, and porrected: thorax embracing the head anteriorly: abdomen oval: legs robust, pubescent; the tarsi short, with bidentate claws. Two lines. *Hippoboscu ovina*, Linn. Found in considerable numbers among the wool of sheep. Another species occurs upon the stag.

Allied to the preceding genus is that named Braula by Dr Nitzsch. The only known species lives upon the honey-bee, and is figured by Germar.[2] It is absolutely blind.[3]

We shall conclude this lengthened exposition of the dipterous order by a few observations on the genus Nycteribia of Lat., *Phthiridium* of Hermann, concerning the true position of which very various opinions have been entertained. The species are in fact entirely apterous, having neither wings nor halteres. They bear a general resemblance to spiders. The head is extremely small, and as it were implanted on the anterior and dorsal portion of the thorax, in the form of a little capsular tubercle. The eyes seem composed of minute grains. The thorax is semicircular. Even Latreille (in his earliest work) was so far misled by the anomalous aspect of these insects as to mistake the very Class to which they belonged. He consequently placed them among the Arachnides. In this he was followed by Dr Leach,[4] who was probably not aware that the great French entomologist had long before rectified his error. When a species of the genus was first observed on a bat by Colonel Montagu, he thought it an entirely new insect, and named it, on account of its rapid movements, *Celeripes Vespertilionis*.[5] It appears, from an expression in the *Fauna Suecica*, that Linnæus described it as a *Pediculus*. The generic name of *Phthiridium*, bestowed by Hermann the younger,[6] being posterior in date to that of Latreille, ought not to be adopted. We may add, that the antennæ, which the German author did not observe, and which he stated did not exist, have been detected by Latreille.[7] They are extremely short, advanced, bi-articulate, and inserted close to each other, on the emargination of the upper edge of the head. The eyes are placed immediately beneath them.

These curious insects, as far as yet known, occur on bats, over which they move with great rapidity; but when withdrawn from their natural nidus they become quite confused, and almost incapable of locomotion. Their heads being placed as it were upon their dorsal aspect, it was difficult to understand how they satisfied their appetite; and we owe to Colonel Montagu the observation, that when they suck the blood of bats they place themselves in a reverse position on their backs. Of the few species known, two are found in Britain, on the greater and the lesser horse-shoe bats. Another species occurs in the Isle of France.[8]

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[1] For a detailed account of the internal structure of these insects, see M. Dufour's *Recherches Anatomiques sur l'Hippobosque des Chevaux*, in the *Ann. des Sciences Nat.* t. vi. p. 299. For their classification, and that of the allied genera, consult Dr Leach's *Insecta Eproboscidea*, in *Memoirs of the Wernerian Society*, vol. ii. p. 547; and *Règne Animal*, t. v. p. 543.

[2] *Fauna Insect. Europ.* vi. 25.

[3] *Règne Animal*, t. v. p. 545.

[4] In the *Supplement* to the preceding edition of this Encyclopædia, vol. i. p. 446. See also *Zool. Miscell.* vol. iii. p. 55.

[5] *Linn. Trans.* vol. ix. p. 166, note.

[6] *Mém. Aptérologique*, p. 124.

[7] *Nouv. Diction. d'Hist. Nat.* art. *Nyctéribie.*

[8] *Diction. Class. d'Hist. Nat.* t. xii. p. 25.

Order IX.—SUCTORIA, Degeer.[1]

In this order the mouth consists of a sucker of three parts (two maxillæ and a ligula), contained between two articulated blades (the labium), forming by their union a trunk or beak, cylindrical or conical, and covered at the base by a pair of scales, supposed to represent the palpi. The species undergo a genuine metamorphosis analogous to that of several Diptera, such as the *Tipulariæ* of Latreille.

The genus Pulex of Linnæus composes the entire order. The body is oval, compressed, covered by a tough integument, and divided into twelve segments, of which the anterior three constitute a short thorax, and the remainder the abdomen. The head is small, much compressed, rounded above, truncated and ciliated in front, and furnished on each side with a little circular eye, behind which, and lodged in a groove, we find certain small moveable articulated bodies, which are the true antennæ. Towards the anterior part of the head, and near the origin of the sucker, are placed another pair of appendages, which Latreille and others have regarded as the antennæ, but which are now with greater propriety considered as maxillæ, or parts of the mouth. Between these is placed the sucker, composed of a bivalvular articulated sheath, and three setæ. The sheath, according to Dugès, corresponds to the labial palpi, while two of the setæ represent the mandibles, and the remaining one is regarded as the analogue of the ligula.

In regard to the species,—"Chacun," says Latreille, "connait la Puce commune." In this country we call it *flea;* and, presuming that it is nearly as well known here as in France, we shall not trouble our readers with a detailed description. The female lays about a dozen eggs, of a white colour, and slightly viscous. From these ere long proceed little lively worms, which move like serpents, or roll themselves about spirally, or in circles. They are at first white, but become ere long of a reddish hue, and are composed of a scaly head, without eyes, furnished with two minute antennæ, and of numerous segments bearing little tufts of hair, and two hooks at the caudal extremity. The mouth exhibits some small moveable pieces, of which the larva makes use in pushing itself forward. They remain about twelve days in that condition, and then each larva encloses itself in a little silk cocoon, where it becomes a nymph, and from which, after about an equal lapse of time, the perfect insect issues forth. The common flea (called by naturalists *Pulex irritans*, see the figure last referred to) occurs in almost all countries. It is parasitical on the bodies of several other animals besides the human kind (of which it prefers children and the gentler sex, owing to the superior softness of their skin), such as dogs, cats, hares, among quadrupeds,—and pigeons, poultry, and swallows, among birds. Defrance, who has published some interesting observations on the eggs and larvæ, has also shown that bathing domestic animals has no effect in ridding them even of the perfect insect, which he has seen resume its wonted functions after a continuous immersion of twenty-two hours. The process, however, is useful, in as far as it appears to annoy the pregnant females, which do not endure immersion above eleven hours. In Dalecarlia the natives place hare-skins in their beds, and other parts of their houses, for the fleas to nestle in. They then destroy them by dipping the skins in hot water, or holding them over a fire.

The genus Pulex is by no means numerous in species. A large yellow kind occurs upon the mole, and a banded species (*P. fasciatus* of Bosc) is found upon the fox. Professor Graham thinks he caught it in Clova. The *Pulex penetrans* of Linn., known to the French colonists of America by the name of *Chique* (Plate CCLII. figure 14), is by some regarded as belonging to a distinct genus. Its sucker is as long as its body (fig. 14, *b*). It introduces itself beneath the toe nails, or under the skin of the feet, where the female speedily acquires a considerable bulk in consequence of the growth of her eggs (fig. 14, *a*). The numerous young to which these give birth sometimes occasion malignant ulcers, difficult to cure, and occasionally mortal. They are extirpated by using a lavement of tobacco juice, or other acrid infusion. The negroes, from frequent practice, extract them with great skill.[2]

Order X.—THYSANOURA, Lat.

The insects of this order, like those of the preceding, are apterous, or without wings. In addition to the usual number of legs, they are provided, either along their sides, or at the extremity of the abdomen, with peculiar organs, which assist the purposes of locomotion. They are masticators, that is, furnished with mandibles and maxillæ. They do not undergo metamorphoses. All the species are of small size, of rather soft consistence, and are generally covered either with shining silvery scales or hairs. They avoid strong light, and seldom quit their retreats till the shades of night have fallen. Some inhabit the interior of houses, keeping themselves concealed in presses, in the interstices of shutters, window-sashes, and other wooden fabrications;—others occur under stones and in humid places. The order is divisible into two families.

Family I.—LEPISMENÆ, Lat.

This family corresponds to the genus *Lepisma* of Linnæus. The antennæ are setaceous, usually very long, and divided from their base into many small articulations. The palpi are distinct and projecting. The abdomen is furnished inferiorly on each side with a range of moveable appendages in the form of false legs, and is terminated by articulated setæ, of which three are more obvious than the others. The body is of an elongated form, and covered with small shining silvery scales. The mouth is composed of a labrum, two almost membranaceous mandibles, a pair of maxillæ, each furnished with a palpus of from five to six articulations, and of a labium of four emarginations, bearing two quadri-articulate palpi. The thorax consists of three perceptible portions. The abdomen, which becomes gradually narrower towards its posterior extremity, is provided, in addition to the false legs just mentioned, with an anal appendage or scaly style, compressed, and composed of two pieces, after which we may observe the three articulated setæ prolonged beyond the body. The legs are rather short—the haunch often very large, much compressed, and squamiform. Several species occur in window-sashes which are seldom opened, beneath the planks of presses where there is any damp or moisture.

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[1] Aptera (pars) Linn.; Siphonaptera, Lat.; Aphaniptera, Kirby.

[2] See *Recherches sur les Caractères Zoologiques du genre Pulex*, par M. Ant. Dugès, in the *Annales des Sciences Nat.* Octobre, 1832; Curtis's *British Entomology*, pl. ccccxvii.; and Mr Westwood *On the Structure of the Antennæ in the Order Aphaniptera*, *Ent. Mag.* vol. i. p. 359.

Thysanoura.

A few seek the protection of stones. They run swiftly, and some leap well by means of their caudal appendages. The Linnæan genus is now divided into two.

In the genus MACHILIS, Lat. (*Petrobius*, Leach), Plate CCLII. figure 8, the eyes are extremely composite, almost contiguous, and occupy the larger portion of the head. The body is convex and arched above, and the abdomen is terminated by small setæ, adapted for leaping, and of which the central one, placed above the others, is much the longest. The maxillary palpi are very large, and pediform. The thorax is narrowed, with its first segment smaller than the others, and arched. These insects leap well and frequently. They dwell in stony and covered places. The species are few in number, and, as far as yet known, are European. We found the *P. maritimus* of Leach[1] in Fingal's Cave, in the island of Staffa.

In the genus LEPISMA properly so called (*Forbicina*, Geoffroy, Leach), Plate CCLII. figure 7, the eyes are very small, distant, and less composite tnan in the preceding genus. The body is flattened, and the three terminal setæ are inserted on the same line, and are not adapted for leaping. The haunches are very large. The greater number are found in the interior of houses. They run swiftly, and when seized their silvery scales come off upon the fingers. The softness of the masticating organs in this genus would induce us to believe that they are incapable of gnawing hard materials. The most common species, *L. saccharina*, is said by Linnæus and Fabricius to feed on sugar and decayed wood,—and, according to the former, it likewise gnaws books and woollen garments. Geoffroy, however, is of opinion that it preys on the little *Psocus pulsatorius*, a small neuropterous insect, usually without wings, which we find both in houses and beneath the bark of trees. This Lepisma measures about four lines in length. It is of a silvery white, with a tinge of lead colour, and without spots. It is said to have come originally from America. Another species, which is represented by the figure last referred to, is distinguished by its ash-coloured body, spotted with black, and marked down the back by four black lines. Its localities are similar to those of the preceding species.

FAMILY II.—PODURELLÆ, LAT.

In this family, which corresponds to the genus *Podura* of Linn., the antennæ consist of only four articulations. The mouth does not exhibit distinct and projecting palpi. The terminal seta is forked, and when not in action is kept bent beneath the abdomen. These insects are extremely small, the body soft, elongated, with an oval head and two eyes, each formed of eight small granules. The legs exhibit only four distinct joints. The tail is soft, flexible, and composed of an inferior piece, moveable at the base, with two articulated appendages at the extremity, susceptible of being approximated, separated, or crossed. By striking this caudal process against the plane of their position, these insects possess the power of leaping into the air like fleas, although with less activity. They generally fall upon their backs, with their tails stretched out behind. Some are found on plants, beneath the bark of trees, or under stones; others on the surface of stagnant waters. They even occasionally occur, during time of thaw, in great quantities, on snow. When collected in numbers, they resemble a sprinkling of gunpowder.

These insects are oviparous, and undergo no transformations. They are completely formed on leaving the egg, although they speedily increase in size, and frequently change their skins. Degeer informs us that he observed them in Holland, alive and active, during the prevalence of a strong frost. The aquatic species do not long survive a removal from the water. They speedily shrivel up and die. But the terrestrial species support uninjured the heat of the mid-day sun even in dry and dusty regions. As far as we know, all the ascertained species are European, though we doubt not the genera exist in other quarters of the globe.

Parasita.

In PODURA properly so called (Plate CCLII. figures 12 and 12 *a*), the antennæ are of nearly equal thickness throughout, and without annuli or small articulations at their extremity. The body is almost linear or cylindrical, with the thorax distinctly articulated, and the abdomen narrow and oblong.

In the genus SMYNTHURUS, Lat. (*Podura*, Linn.), the antennæ become attenuated towards the extremity, and are terminated by an annulated portion, composed of small articulations. The thorax and abdomen seem united into a single globular or ovate mass. This genus corresponds to the second section of the *Poduræ* of Degeer. When touched, these insects make great leaps into the air by means of a setiform process at the end of the abdomen, resembling that of the preceding genus;—but they are moreover furnished with a very extraordinary organ, which we do not find in Podura proper. Beneath their body, and just between the points of the two forks of the tail, there exists an elevated cylindrical portion, from which issue two long membranous threads, transparent, extremely flexible, and glutinous or humid. They are rounded at the extremity, almost as long as the insect's body, and are thrown out with force and celerity, one on either side, from the cylindrical portion just mentioned, according to the insect's pleasure.

In regard to the uses of these peculiar parts of structure, Degeer observed that some Smynthuri which he had placed in an earthen vessel ejected their slimy organs whenever they found themselves, against their will, slipping down the sides of their prison. They then hung, as it were, suspended by these filaments, until they had time to take up a fresh position.[2] It may thus be reasonably inferred that their natural use or function is to prevent the insect's falling, when, after the execution of a powerful leap, it happens to alight upon a perpendicular or inclined surface. Degeer's observations apply to *Sm. fuscus*, Lat.,[3] a comparatively large species, synonymous with *Podura atra* of Linn.

ORDER XI.—PARASITA, LAT.[4]

The insects of this, our concluding order, are apterous, like those of the preceding; but their bodies are unprovided with articulated appendages, or other organs of locomotion, except the legs. Their organs of sight seem to consist solely of smooth or simple eyes (*yeux lisses*). Their mouth is in great part internal, and exhibits externally either a muzzle or projecting protuberance, enclosing a retractile sucker, or two membranaceous approximate lips, with a pair of hooked mandibles. These insects form in the Linnæan system the genus PEDICULUS, containing an extensive and varied group, known under the general and repulsive name of *lice*, and exhibiting in their structure and economy a great deal to interest the philosophi-

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[1] *Zoological Miscellany*, cxlv.

[2] *Mémoires*, t. vii. p. 35, pl. iii. figs. 7, 8.

[3] *Genera Crustac. et Insect.* t. i. p. 166.

[4] APTERA (pars) Linn.; ANOPLURA, Leach.

cal naturalist, notwithstanding the associations by which we unavoidably connect their existence with that of wretchedness and vice.

The unrestricted genus may be said to be generally characterized by a flattened body, almost transparent, and divided into eleven or twelve distinct segments, of which the anterior three bear the six legs. The first of these segments often assumes the form of a thorax. The stigmatic openings are very distinct. The antennæ are short, of uniform thickness, composed of five articulations, and frequently inserted in an emargination. On each side of the head there are one or two small simple eyes. The legs are rather short, and are terminated by a very strong claw, or by a couple of hooks directed one towards the other. These parasites, as many know by experience, attach themselves to man, beast, and feathered fowls. They likewise fix their eggs to hair and feathers; and as their generations are neither few nor far between, their superabundant increase under certain circumstances, not yet clearly understood, is sometimes such as to produce disease and death. The malady is called *phthiriasis*, from φθείρ, the Greek for louse.[1] Fabricius placed the Pediculi in his order *Antliata* (or Diptera), guided no doubt by a consideration of the parts of the mouth; while Dr Nitzsch, who has studied these insects with great attention, now ranks them with the Hemiptera, and at the same time classes the cognate genus Ricinus in the orthopterous order.

In the genus Pediculus properly so called (Plate CCLII. figures 11 and 11 *a*), the mouth is very small, mammillæform, and tubular, placed at the anterior extremity of the head, and, while not in action, enclosing a sucker. The tarsi consist of an articulation almost equal in size to the tibia, and terminated by a very strong claw, which, bending inwards upon a small projection, forms as it were a kind of nipper. Such of the species as Latreille has examined presented only a pair of simple eyes, one on each side.

Of the three species which infest the human race, *P. humanus corporis* is without spots. It infests the inner garments of beggars, and others who attach no importance to personal cleanliness, and is the cause of the disease above alluded to. The second species, *P. humanus capitis*, is more of an ash colour, with brown or blackish spots around the stigmatic openings, and the lobes of the abdomen are more salient. It occurs on the heads of children, and of dirty adults. In both these species the head and thorax are obviously distinct from the abdomen. In the third species, which forms the genus *Phthirus* of Dr Leach, the body is broad and rounded, the thorax very short and almost confounded with the abdomen, and the four posterior legs are very strong.

Of all these insects the powers of multiplication are great. Swammerdam viewed them as hermaphrodites, in as far as he could not satisfy himself regarding their distinctive sexual characters. But Leeuwenhoeck and Degeer, and recently Latreille and Doctors Nitzsch and Alibert, have shown that they do not differ essentially in these respects from other allied tribes. They are all oviparous, and their eggs are deposited on hair (see Plate CCLII. fig. 11 *b*) or garments. The young are hatched in five or six days, and after several castings of their skin, or in about eighteen days, they become fit to reproduce their kind. In this way it has been calculated that a brace of females may prove the parents of *eighteen thousand young* in the space of two months. Oviedo remarked that the pediculi left the Spanish sailors at a certain latitude during their voyage to the Indies, and made their appearance again on the homeward progress about the same latitude. This we think was somewhere near the tropics; but the observation does not seem to have been confirmed by any special observations in more modern times. It is said, however, that in India they occur only on the head. These insects, however disgusting to people of refinement, are greedily sought after and *eaten* by those who may by some be regarded as belonging to the inferior orders, viz. Negroes, Hottentots, and Monkeys.

In the genus Ricinus of Lat. (Plate CCLII. figure 10), which corresponds to *Nirmus* of Hermann and Leach, the mouth is placed beneath, and consists exteriorly of two lips, and a pair of hooked maxillæ.[2] These insects, with the exception of a species found on dogs, are all bird-lice, that is, parasitical on the feathered creation. Their head, which, in common with the antennæ, occasionally differs in the sexes, is usually very large,—in some of a triangular form, in others semicircular or lunate,—and is frequently furnished with angular projections. Latreille has perceived a pair of simple eyes on each side of the head in several species. Besides the parts of the mouth just mentioned, Savigny satisfied himself of the presence of maxillæ, each bearing a very small palpus, and concealed by the labium or lower lip, which is also palpigerous. There is likewise a kind of tongue. The Ricini are much less sluggish in their movements than the Pediculi properly so called. They glide about among the feathers of birds with considerable agility, and are captured with difficulty, by reason of the flatness of their forms and adhesive propensities. When a bird dies, however, they assemble together about the base of the beak, and other parts of the head, and moving about with an air of inquietude, they seem to watch for an opportunity of making their escape to some living prey. M. Leclerc de Laval detected portions of the plumage in their stomachs, and he is of opinion that these constitute their sole subsistence; but Degeer found the Ricinus of the chaffinch gorged with blood; and their extreme anxiety to change their quarters the moment that circulation ceases, argues a fancy for something more than feathers.

We have at last brought to a conclusion an article which the reader may possibly regard as of inordinate length, but which the writer has certainly found far too narrow for the proper elucidation of several departments of his subject. " And here it is not out of place to remark, that it is the very perfection of the divine workmanship which leads every inquirer to imagine a surpassing worth, and grace, and dignity, in his own special department of it. The fact is altogether notorious, that in order to attain a high sense of the importance of any science, and of the worth and beauty of the objects which it embraces, nothing more is necessary than the intent and persevering study of them. Whatever the walk of philosophy may be on which man shall enter, that is the walk which of all others he conceives to be most enriched by all that is fitted to entertain the intellect or arrest the admiration of the enamoured scholar. The astronomer who can unravel the mechanism of the heavens, or the chemist who can trace the atomic processes of matter

[1] It is well described by M. Alibert, in his treatise *Sur les Maladies de la Peau.*

[2] The genus Ricinus was established by Degeer, who first recognised that these insects were distinguished from Pediculi by the existence of mandibles. The name was applied by the ancients to certain acarideous species of the genus now called *Ixodes*, and for that reason has not been adopted by some modern naturalists, who prefer the name of *Nirmus*.

upon earth, or the metaphysician who can assign the laws of human thought, or the grammarian who can discriminate the niceties of language, or the naturalist who can classify the flowers, and the birds, and the shells, and the minerals, and the insects which so teem and multiply in this world of wonders,—each of these respective inquirers is apt to become the worshipper of his own theme, and to look with a sort of indifference, bordering on contempt, towards what he imagines the far less interesting track of his fellow-labourers. Now each is right in the admiration he renders to the grace and grandeur of that field which himself has explored; but all are wrong in the distaste they feel, or rather in the disregard they cast on the other fields which they have never entered. We should take the testimony of each to the worth of that which he does know, and reject the testimony of each to the comparative worthlessness of that which he does not know; and then the unavoidable inference is, that that must be indeed a replete and a gorgeous universe in which we dwell,—and still more glorious the Eternal Mind, from whose conception it arose, and whose prolific fiat gave birth to in all its vastness and variety."[1] (J. W.)

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[1] Chalmers' Bridgewater Treatise *On the Adaptation of External Nature to the Moral and Intellectual Constitution of Man*, vol. ii., p. 173.

ENTOZOA, a name given to an extensive series of parasitical animals which infest the internal organs of other animals. See ZOOPHYTES, § *Intestinal Worms.*

ENTRE DUERO E MINHO, or MINHO, the most northern of the provinces into which the kingdom of Portugal is divided. As its name denotes, it is bounded on the north by the river Minho (which divides it from Spain), and on the south by the river Duero. The Atlantic Ocean is its western boundary, and on the east a chain of elevated mountains separates it from the province of Tras os Montes. It lies between 41. 5. and 42. 8. N. Lat., and between 7. 48. and 8. 45. W. Long., being about 70 miles in length from N. to S., and 45 miles in breadth from E. to W. It is divided into two districts, having areas (in English square miles) and populations as follows:—

Districts.	Area.	Pop. in 1851.
Vianna	952	184,359
Braga	1083	297,969
	2035	482,328

Three mountain ranges traverse this province from N.E. to S.W. The most northern and loftiest of these, the Serra de Estrica, occupies nearly the whole of the territory between the Minho and the Lima. Its highest summit rises to the height of nearly 7900 feet. The central range, called the Serra de Geres, occupies the country between the Lima and the Cavado; while the Serra de Santa Catarina runs nearly parallel to the Tamega, and afterwards extends westward towards the sea. The rivers next in importance to those which bound the province, are the Lima and the Cavado (both of which flow into the sea), and the Tamega an affluent of the Douro. The province is also watered by numerous smaller rivers and streams; and, particularly in the valleys, is exceedingly fertile and well cultivated. The principal productions are wine, oil, flax, oranges, lemons, maize, wheat, barley, and oats. The staple production, however, is wine, which indeed forms the principal article of export of the kingdom; and the well-known red wine, denominated port (from Oporto, whence it is shipped), is almost wholly the growth of this province. The climate is pleasant and salubrious, the heat of summer being tempered by the sea breezes, while the winters are very mild. The sea and rivers abound with excellent fish, the capture of which affords employment to a considerable portion of the inhabitants. The principal manufactures are linen, woollen, and silk goods, hats, porcelain, hardware, and cutlery. The capital of the province is Braga.

ENVOY (Fr. *envoyer, to send*), a person deputed to negotiate a treaty, or to transact other business with a foreign prince or government. Envoys belong to the second order of diplomatic ministers; ranking below ambassadors properly so called. (See AMBASSADOR.)

ENYED NAGY, a market-town of Transylvania, not far from the Maros, and 18 miles N.N.E. of Carlsburg. Pop. about 5500. It has a richly endowed Protestant lyceum, besides a Roman Catholic, Lutheran, and other churches. It was originally a Saxon town, and the streets still retain their Saxon names. The adjoining country is chiefly occupied by large and valuable vineyards.

ENZELLI, a town of Persia, province of Ghilan, situated on a small tongue of land between the Caspian and the Gulf of Enzelli, 18 miles N.W. of Reshd. The town is built entirely of reeds, as the sandy soil will not support more weighty materials. Pop. about 3000, chiefly Russians.

EOCENE PERIOD (ἕως *dawn*, καινός *recent*), in *Geology*, the name given by Sir C. Lyell to the earliest of the four periods of the tertiary strata, because, as he remarks—"the extremely small proportion of living species contained in these strata indicates what may be considered the first *dawn* of the existing state of the animate creation."

EOLIPILE. See ÆOLIPILE; and BLOW-PIPE, § *Eolipile.*

EOLODICON, a musical instrument invented about 1815 by Eschenbach, an officer of the royal exchequer at Königshof in Bohemia, and constructed, a few years afterwards, by Voit, a maker of musical instruments at Schweinfurt, in Franconia. A notice of the instrument was published at Leipzig, in 1820; and another in the *Bibliographie Musicale*, Paris, Niogret, 1822. The eolodicon was played by a set of keys like those of a pianoforte, and its resonant mechanism consisted of a number of metal springs, fixed at one end and free at the other, which were thrown into vibration by a current of air from a bellows under the control of the player. Many instruments on the same principle have since then been constructed; and among these are the recent "Orgue Expressif," and the "Harmonion," made at Paris and elsewhere. (G. F. G.)

EOOA, or MIDDLEBURG, is the most eastern of the Friendly Islands, in the South Pacific Ocean. It is about 30 miles in circuit, and has an elevated and unequal surface. The N.E. coast rises suddenly, but the N.W. consists of valleys, meadows, and plains, abounding with groves of fruit-trees, sugar-canes, bananas, shaddocks, and vegetables of various sorts. It was discovered in 1643, by Tasman, who called it Middleburg. E. Long. 175. 30., S. Lat. 18. 24.

EORA, in *Antiquity*, a festival instituted at Athens in memory of Erigone the daughter of Icarius. This prince had given wine to some shepherds, who, being unaware of its intoxicating qualities, partook of it to excess; and under the impression that it was poison, killed Icarius. Erigone long sought for his body in vain; till at last, guided by a faithful dog, she discovered it. Overwhelmed with grief, she hanged herself—praying with her last breath that all the Athenian maidens might come to a similar end. As if her prayers had been heard, it so happened that a mania for this kind of death exhibited itself soon after among the Athenian women; and when the oracle was consulted on the subject, it replied that Erigone must be propitiated with a festival. It was customary for the Athenian maids who took part in its celebration to swing themselves, singing at the same time a song composed for the occasion by Theodorus of Colophon.

EOS, or AURORA. See AURORA.

EOSTRE, a Saxon goddess to whom sacrifices were offered in the month called *Eostra* (April); and hence the name *Easter*, which the Saxons, after their conversion to Christianity, applied to the festival celebrated in commemoration of our Saviour's resurrection.

EPACT (ἐπακτος, *added*), in *Chronology*, a term employed in the calendar to express the moon's age at the end of the year; or the excess of the solar month above the lunar synodical month, and of the solar year above the lunar year of twelve synodical months. See CALENDAR, vol. vi. p. 83, *et seq.*

EPAMINONDAS, a celebrated Theban general, who, along with Pelopidas, achieved a series of victories over the Spartans. He was killed at the battle of Mantinea B.C. 362, and was buried on the field. The history of this celebrated commander, with an account of his exploits, will be found detailed at length under the head THEBES.

EPAULEMENT (Fr. *épaule, a shoulder*), in *Fortification*, a kind of breast-work, constructed to cover the troops in front, and sometimes also in flank. In a siege, an epaulement of 8 or 10 feet in height is generally raised near the entrance of the approaches, in order to cover the cavalry placed there to support the guard of the trenches. Epaulements are commonly constructed of filled gabions, or of fascines and earth intermixed. The term is frequently applied to any work thrown up to defend the flank of a post or other place; as also to a demi-bastion, or to a square orillon for covering the cannon of a casemate.

EPAULETTE (Fr. *épaule, a shoulder*), a kind of shoulder-knot or ornamental badge worn on the shoulder by military men. Officers, both naval and military, wear epaulettes on one shoulder or on both, according to their rank in the service.

EPENTHESIS, in *Grammar*, the insertion of a letter or syllable in the middle of a word; as *alituum* for *alitum*, *induperator* for *imperator*.

EPERIES, a royal free town of Hungary, capital of the county of Saros; on the Tarcza, an affluent of the Theiss; 140 miles N.E. of Pesth. Pop. 8600. It is well built, and surrounded with walls, outside of which are extensive gardens. The public buildings include a Lutheran and several Roman Catholic churches, a synagogue, high schools, county and town halls, chapter-house, monastery, and orphan asylum. It is the seat of a Greek Catholic bishop, and has an episcopal library, and a prayer station called a *Calvary*, much resorted to by the religious. Eperies has manufactures of linen and woollen goods, earthenware, and beer; and a considerable trade in wine, corn, and cattle. In the vicinity are the royal Sovár salt-works, which annually produce about 5000 tons of salt.

EPERNAY (the ancient *Aquæ Perennes*), a town of France, in the department of Marne, and capital of a cognominal arrondissement. It is situated near the left bank of the Marne, 20 miles W.N.W. of Chalons. Pop. (1851) 7386. This was formerly a place of some strength, but its fortifications have fallen into decay. The town is neat, clean, and tolerably well built. It is best known as being the principal entrepot for Champagne wines, which are kept here bottled in extensive vaults excavated in the sandstone on which the town is built.

EPEUNACTÆ, or Epeunætæ, in *Grecian Antiquity*, were a class of Spartan citizens believed to have sprung from the union of the Helots with the widows of the Spartans who had fallen in the Messenian war. They seem to have been identical with the Partheniæ; who, finding themselves excluded from the privileges which they believed their due, and classed with Helots, conspired with them to make war on their oppressors. This unnatural war, however, was soon brought to a close; and the Partheniæ emigrated in a body under the command of Phalanthus to Italy, where they founded Tarentum.

EPHAH, in *Jewish Antiquity*, a dry measure of capacity, equivalent to the *bath* for liquids. It contained three pecks and three pints.

EPHEBEUM, in *Antiquity*, a hall set apart for the youth in the palæstra. See Gymnasium.

EPHEBI, in *Grecian Antiquity*, the name given to the Attic youth from the age of eighteen till they entered upon their twentieth year. During this period they served a sort of apprenticeship in arms, and were frequently sent, under the name of *peripoli*, to some of the frontier towns of Attica to keep watch against foreign invasion. It is not precisely determined whether the ephebi enjoyed all the rights of citizens; but the most received opinion is, that they were entitled to some of them at least. The well-known instance of Demosthenes, who at the age of eighteen prosecuted his guardians for mismanaging his property, is a confirmation of this idea.

EPHEMERA (ἐπί, and ἡμέρα *a day*), a fever of one day's continuance only. Ephemera is also used to designate a fly that lives but one day, or any insect that is very short-lived.

EPHEMERIS, a journal or account of daily transactions; a diary.

In *Astronomy*, it denotes an account of the daily state or positions of the planets; that is, a table, or a collection of tables, exhibiting the places of the planets each day at noon. It is from these tables that the eclipses, conjunctions, and other aspects of the planets, are calculated. The principal works of this kind are our own *Nautical Almanack*, the Berlin *Jahrbuch*, and the French *Connaissance des Temps*. See Astronomy.

EPHESIANS, Epistle to the, one of the canonical books of the New Testament. It was written by the apostle Paul during the earlier part of his imprisonment at Rome, at the same time with the Epistle to the Colossians. Its genuineness, which was at one time opposed, seems now universally admitted; but its original destination is a point on which much learned controversy has been waged. In opposition to the common opinion that it was addressed to the church of Ephesus, Grotius (reviving the opinion of Marcion) regards it as originally sent to the church at Laodicea; while Usher seeks to escape from the difficulties of either supposition, by regarding it as a circular letter without any designation to any particular church. The common opinion is now generally preferred.

EPHESUS, in *Ancient Geography*, an old and celebrated city, capital of Ionia, and one of the twelve Ionian cities in Asia Minor in the mythic times. It was said to have been founded by the Amazons, to have been in later ages inhabited by the Carians and Leleges, and finally taken possession of by the Ionians, under Androclus, the son of Codrus. It lay on the river Cayster, not far from the coast of the Icarian sea, between Smyrna and Miletus. It was also one of the most considerable of the Greek cities in Asia Minor; but while, about the epoch of the introduction of Christianity, the other cities declined, Ephesus rose more and more. It owed its prosperity in part to the favour of its governors (for Lysimachus named the city Arsinoë, in honour of his second wife, and Attalus Philadelphus furnished it with splendid wharfs and docks); in part to the favourable position of the place, which naturally made it the emporium of Asia on this side the Taurus (Strabo, xiv. pp. 641, 663). Under the Romans, Ephesus was the capital not only of Ionia, but of the entire province of Asia, and bore the honourable title of the *first and greatest metropolis of Asia* (Boeckh, *Corp. Inscr. Gr.* 2968–2992). The bishop of Ephesus in later times was the president of the Asiatic dioceses, with the rights and privileges of a patriarch (Evagr. *Hist. Eccl.* iii. 6). In the days of Paul, Jews were found settled in the city in no inconsiderable number, and from them the apostle collected a Christian community; which, being fostered and extended by the hand of Paul himself, became the centre of Christianity in Asia Minor.

The classic celebrity of this city is chiefly owing to its famous temple, and the goddess in whose honour it was built, namely, "Diana of the Ephesians."

Around the image of the goddess was afterwards erected, according to Callimachus (*Hymn. in Dian.* 248), a large and splendid temple:

——— τοῦ δ' οὔ τι θεώτερον ὄψεται ἠώς
Οὐδ' ἀφνειότερον· ῥέα κεν Πυθῶνα παρέλθοι.

This temple was burnt down on the night in which Alexander was born, by an obscure person of the name of Erostratus, who thus sought to transmit his name to posterity; and, as it seemed somewhat unaccountable that the goddess should permit a place which redounded so much to her honour to be thus recklessly destroyed, it was given out that Diana was so engaged with Olympias, in aiding to bring Alexander into the world, that she had no time nor thought for any other concern. At a subsequent period, Alexander made an offer to rebuild the temple, provided he was allowed to inscribe his name on the front, which the Ephesians refused. Aided, however, by the whole of Asia Minor, they succeeded in erecting a still more magnificent temple, which the ancients have lavishly praised, and placed among the seven wonders of the world. It took 220 years to complete. Pliny (*Hist. Nat.* xxxvi. 21), who has given a description of it, says it was 425 feet in length, 220 broad, and supported by 127 columns, each of which had been contributed

Ephesus. by some prince and was 60 feet high; 36 of them were richly carved. Chersiphron, the architect, presided over the undertaking; and, being ready to lay violent hands on himself in consequence of his difficulties, was restrained by the command of the goddess, who appeared to him during the night, assuring him that she herself had accomplished that which had brought him to despair. The altar was the work of Praxiteles. The famous sculptor Scopas is said by Pliny to have chiselled one of the columns. Apelles, a native of the city, contributed a splendid picture of Alexander the Great. The rights of sanctuary, to the extent of a stadium in all directions round the temple, were also conceded; which, in consequence of abuse, the emperor Tiberius abolished. The temple was built of cedar, cypress, white marble, and even gold, with which it glittered (Spanh. *Observat. in Hymn. in Dian.* 353). Costly and magnificent offerings of various kinds were made to the goddess, and treasured in the temple; such as paintings, statues, &c., the value of which almost exceeded computation. The fame of the temple, of the goddess, and of the city itself, was spread not only through Asia, but the world; a celebrity which was enhanced and diffused the more readily because sacred games were practised there, which called competitors and spectators from every country. Among his other enormities, Nero is said to have despoiled the temple of Diana of much of its treasure: yet it continued to command no small portion of respect, till it was finally burnt by the Goths in the reign of Gallienus.

At Ephesus Diana was worshipped under the name of Artemis. There was more than one divinity that went by the name of Artemis—as the Arcadian Artemis, the Taurian Artemis, as well as the Ephesian Artemis. The Ephesian Artemis (see ARTEMIS and DIANA) differed materially from the Diana, sister of Apollo, whose attributes are the bow, the quiver, the girt-up robe, and the hound; whose person is a model of feminine strength, ease, and grace;, and whose delights were in the pursuits of the chase—

> Along the shady hills and breezy peaks
> Rejoicing in the chase, her golden bow
> She bends, her deadly arrows sending forth.

Among the distinguished natives of Ephesus in the ancient world, may be mentioned Apelles and Parrhasius, rivals in the art of painting; Heraclitus, the man-hating philosopher; Hipponax, a satirical poet; Artemidorus, who wrote a history and description of the earth. The claims of Ephesus, however, to the praise of originality in the prosecution of the liberal arts, are quite inconsiderable; and it must be content with the dubious reputation of having excelled in the refinements of a voluptuous and artificial civilization. With culture of this kind, a practical belief in, and a constant use of, those arts which pretend to lay open the secrets of nature and arm the hand of man with supernatural powers, have generally been found conjoined. Accordingly, the Ephesian multitude were addicted to sorcery; indeed, in the age of Christ and his apostles, adepts in the occult sciences were numerous; they travelled from country to country, and were found in great numbers in Asia, deceiving the credulous multitude and profiting by their expectations. They were sometimes Jews, who referred their skill and even their forms of proceeding to Solomon, who is still regarded in the East as head or prince of magicians (Joseph. *Antiq.* viii. 2, 5; Acts viii. 9; xiii. 6, 8). In Asia Minor Ephesus had a high reputation for magical arts (Ortlob, *De Ephes. Libris combustis*).

The books mentioned Acts xix. 19 were doubtless books of magic. How much used and prized they were, may be learnt from the fact that "the price of them" was "fifty thousand pieces of silver." Very celebrated were the Ephesian letters, which appear to have been a sort of magical formulæ, written on paper or parchment, designed to be fixed as amulets on different parts of the body, such as the hands and the head (Plut. *Sym.* vii.; Lakemacher, *Obs. Philol.* ii. 126; Deyling, *Observ.* iii. 355). Erasmus (*Adag. Cent.* ii. 578) says that they were certain signs or marks which rendered their possessor victorious in everything. Eustathius (*ad Hom. Odys.* τ 694) states an opinion that Crœsus, when on his funeral pile, was very much benefited by the use of them; and that when a Milesian and an Ephesian were wrestling in the Olympic games, the former could gain no advantage, as the latter had Ephesian letters bound round his heel; but these being discovered and removed, he lost his superiority and was thrown thirty times. Ephesus.

The ruins of Ephesus lie two short days' journey from Smyrna, in proceeding from which towards the south-east the traveller passes the pretty village of Sedekuy; and two hours and a half onwards he comes to the ruined village of Danizzi, on a wide, solitary, uncultivated plain, beyond which several burial-grounds may be observed; near one of these, on an eminence, are the sole remains of Ephesus, consisting of shattered walls, in which some pillars, architraves, and fragments of marble have been built. The soil of the plain appears rich. It is covered with a rank, burnt-up vegetation, and is everywhere deserted and solitary, though bordered by picturesque mountains. A few corn-fields are scattered along the site of the ancient city, which is marked by some large masses of shapeless ruins and stone walls. Towards the sea extends the ancient port, a pestilential marsh. Along the slope of the mountain and over the plain are scattered fragments of masonry and detached ruins, but nothing can now be fixed upon as the great temple of Diana. There are some broken columns and capitals of the Corinthian order of white marble; there are also ruins of a theatre, consisting of some circular seats and numerous arches—supposed to be the one in which Paul was preaching when interrupted by shouts of "Great is Diana of the Ephesians." The ruins of this theatre present a wreck of immense grandeur, and the original must have been of the largest and most imposing dimensions. Its form alone can now be spoken of, for every seat is removed, and the proscenium is a hill of ruins. A splendid circus (Fellows' *Reports*. p. 275) or stadium remains tolerably entire, and there are numerous piles of buildings seen alike at Pergamus and Troy as well as here—by some called gymnasia, by others temples; by others, again, with more propriety, palaces. They all came with the Roman conquest. No one but a Roman emperor could have conceived such structures. In Italy they have parallels in Adrian's villa near Tivoli, and perhaps in the pile upon the Palatine. Many other walls remain to show the extent of the buildings of the city, but no inscription or ornament is to be found, cities having been built out of this quarry of worked marble. The ruins of the adjoining town, which arose about four hundred years ago, are entirely composed of materials from Ephesus. There are a few huts within these ruins (about a mile and a half from Ephesus) which still retain the name of the parent city, *Asalook*—a Turkish word which is associated with the same idea as Ephesus, meaning the city of the moon (*Fellows*). A church dedicated to St John is thought to have stood near, if not on the site of the present mosque. Arundell (*Discoveries*, vol. ii. p. 253) conjectures that the gate called the Gate of Persecution, and large masses of brick wall which lie beyond it, are parts of this celebrated church which was fortified during the great Council of Ephesus. The tomb of St John was in or under his church; and the Greeks have a tradition of a sacred dust arising every year, on his festival, from the tomb, possessed of miraculous virtues: this dust they term manna. Not far from the tomb of St John was that of Timothy. The tomb of Mary, the mother of our Lord, and the seven παιδία (boys, as the *Synaxaria* calls the Seven Sleepers) are found in an adjoining hill. At the back of the mosque, on the hill, is the sunk ground-plan of a small church, still much venerated by the Greeks. The

sites of two others are shown at Asalook. There is also a building called the Prison of St Paul, constructed of large stones without cement.

Though Ephesus presents few traces of human life, and little but scattered and mutilated remains of its ancient grandeur, yet the environs—diversified as they are with hill and dale, and not scantily supplied with wood and water—present many features of great beauty. Arundell (ii. 244) enumerates a great variety of trees which he saw in the neighbourhood, among which may be specified groves of myrtle near Ephesus. He also found heath in abundance, of two varieties; and saw there the common fern, which he met with in no other part of Asia Minor.

Dr Chandler (p. 150, 4to) gives a striking description of Ephesus, as he found it on his visit in 1764:—"Its population consisted of a few Greek peasants, living in extreme wretchedness, dependence, and insensibility; the representatives of an illustrious people, and inhabiting the wreck of their greatness—some the substructure of the glorious edifices which they raised; some beneath the vaults of the stadium, once the crowded scene of their diversions; and some in the abrupt precipice, in the sepulchres which received their ashes. Such are the present citizens of Ephesus, and such is the condition to which that renowned city has been reduced. It was a ruinous place when the emperor Justinian filled Constantinople with its statues, and raised the church of St Sophia on its columns. Its streets are obscured and overgrown. A herd of goats was driven to it for shelter from the sun at noon, and a noisy flight of crows from the quarries seemed to insult its silence. We heard the partridge call in the area of the theatre and of the stadium. The pomp of its heathen worship is no longer remembered; and Christianity, which was then nursed by apostles, and fostered by general councils, barely lingers on, in an existence hardly visible." However much the church at Ephesus (Rev. ii. 2) may, in its earlier days, have merited praise for its "works, labour, and patience," yet it appears soon to have "left its first love," and to have received in vain the admonition—"Remember, therefore, from whence thou art fallen, and repent and do the first works; or else I will come unto thee quickly, and will remove thy candlestick out of its place, except thou repent." If any repentance was produced by this solemn warning, its effects were not durable; and the place has long since offered an evidence of the truth of prophecy and the certainty of the divine threatenings, as well as a melancholy subject for thought to the contemplative Christian. Its fate is that of the once-flourishing seven churches of Asia; its fate is that of the entire country—a garden has become a desert. Busy centres of civilization, spots where the refinements and delights of the age were collected, are now a prey to silence, destruction, and death. Consecrated first of all to the purposes of idolatry, Ephesus next had Christian temples almost rivalling the pagan in splendour, wherein the image of the great Diana lay prostrate before the cross; and, after the lapse of some centuries, Jesus gives place to Mohammed, and the crescent glittered on the dome of the recently Christian church. A few more scores of years, and Ephesus has neither temple, cross, crescent, nor city; but is "a desolation, a dry land, and a wilderness." Even the sea has retired from the scene of devastation, and a pestilential morass, covered with mud and rushes, has succeeded to the waters which brought up ships laden with merchandise from every part of the known world (Herod. i. 26, ii. 148; Liv. i. 45; Pausan. vii. 2, 4; Philo, *Byz. de 7 Orb. Mirac.* Gronov. *Thesaur.* viii.; Creuzer, *Symbol.* ii. 13; Hasel, *Erdbeschr.* ii. 132; for a plan of Ephesus, see Kiepert' Atlas, von Hellas; Arundell's *Visit to the Seven Churches of Asia;* Fellows' *Excursion in Asia Minor*, 1839; *Discoveries in Asia Minor*, by Rev. T. Arundell, 1834).

EPHETÆ, in *Grecian Antiquity*, a judicial tribunal at Athens, consisting of 51 members, one of the terms of whose admission to office was that they should be not under fifty years of age. It was a court of great antiquity, and was believed to be coeval with the Areopagus itself. Originally the ephetæ sat in all the five courts; but in later times they only sat in four of them, viz., the Palladium, the Prytaneum, the Delphinium, and the Phreatto. In the Palladium they tried cases of accidental homicide; in the Delphinium, of justifiable homicide; in the Prytaneum they passed sentence upon the instrument with which a murder had been committed, if the real murderer could not be detected. In the Phreatto they tried such murders as might have been committed by Athenian citizens, who for accidental or justifiable homicide had been condemned to temporary exile. In course of time the cases which came before the ephetæ were of so trifling and unimportant a nature that the court fell altogether into disrepute. (See Plutarch, *Solon*, xix., 29; *Pollux*, viii. 125; Thirlwall's *Hist. of Greece*, vol. ii.)

EPHOD, in *Jewish Antiquity*, the designation of a part of the priestly habiliments. It was a short cloak covering the shoulders and breast. The ephod of the inferior priests was simply of linen; while that of the high priest was made of gold, of blue, of purple, of scarlet, and fine twined linen cunningly wrought. Though it probably consisted of one piece, woven throughout, it had a back part and a front part, united by shoulder-pieces. It had also a girdle; or rather it had strings at each side by which it was tied to the body. On each shoulder was an onyx stone, set in gold; and upon each stone were engraven six of the names of the children of Israel, according to the precedence of birth, to memorialize the Lord of the promises made to them (Exod. xxviii.) Josephus gives sleeves to the ephod (*Antiq.* iii. 7, 5). It may be considered as a substitute for the leopard-skin worn by the Egyptian high priests in their most sacred duties. The Egyptian ephod is, however, highly charged with all sorts of idolatrous figures and emblems, and even with scenes of human sacrifices.

EPHORI, ancient Doric magistrates, whose power and influence seem to have varied at different times. In Sparta the college consisted of five, and these entered on their annual office at the autumnal solstice, the beginning of the Lacedæmonian year. The first of these magistrates gave name to the year, in the same way as the first elected archon did at Athens; and they began their official duties by publishing a species of edicts, in which they appointed the secret officers or κρύπτοι. In this edict was found the strange metaphorical expression for subjection and obedience, "that they must shave the beard and obey the laws." They held their daily meetings in an office set apart for them (ἀρχεῖον), where they were also in the habit of eating together.

It is supposed by Müller, in his able treatise on the political institutions of the Dorians, that the duties of the ephori were originally limited to the superintendence of sales and of the public markets. Aristotle informs us, while describing their judicial powers, that they decided civil causes, but that the council presided over all capital crimes. It appears therefore that the court of ephori gave judgment respecting civil duties and property. The Periœci and Helots, when they were in Sparta, were also under its jurisdiction. But the ephori gradually extended their authority; and it seems to have been the usual course of events in Greece, that the civil courts should enlarge their influence, whilst the power of the criminal courts was continually on the decline.

The circumstance which seems principally to have extended the jurisdiction of the ephori, was the privilege they enjoyed of instituting an inquiry into the official conduct of all magistrates, excepting that of councillors. We do not mean to say that this scrutiny always took place; but the ephori had it in their power to compel any magistrate to stand his trial, if they had remarked anything suspicious in

Ephorus.

his administration. The king was not exempted from this power, but bound to yield as implicit obedience as the lowest officer of the state. Thus we find Cleomenes tried for bribery before the Persian war. But it must not be supposed that the ephori could of themselves punish with death: they were only the accusers before a larger court, which consisted of all the councillors, of the ephori themselves (who seem to have acted both as accusers and judges), of the other king, and probably of several other magistrates, who had all equal votes. The ephori had only the power to impose fines, and to demand immediate payment. Thus Agesilaus was fined for endeavouring to make himself popular; whilst Archidamus was reprimanded for having married a wife of too small stature. Sometimes we find them punishing one man for having introduced money into the state, another for indolence, and a third for the most extraordinary reason, namely, that he was generally ill treated and insulted.

The ephori appear from very ancient times to have had a right to transact business with the popular assembly in preference to any other magistrates. They could convene the people and put the vote to them. They had great authority in transacting with foreign nations, admitting ambassadors, and dismissing them from the confines of the kingdom. In time of war they were empowered to send troops on whatever day they thought fit, and seem even to have been able to determine the number of men. The army was then intrusted to the king, or some other general, who received from them instructions how to act, and was even restrained in his proceedings by deputies whom the ephori sent to watch over him. The generals could be recalled by the scytala, and their first duty was to visit the office of the ephori. It is impossible, however, to believe that the ephori could act by their own authority on such important occasions as these; they could only have been the agents and plenipotentiaries of the popular assembly. It must in fact have been the decrees of the people which they put in execution.

The office of the ephori was abolished by Cleomenes, but restored under the Roman dominion. (See Müller's *Dorier*, Breslau, 1824, t. ii. p. 111–129.)

EPHORUS, a Greek historian of Cumæ in Æolis, born about 405 B.C. His father's name was Demophilus, or Antiochus; and being contemporary with Eudoxus and Theopompus, he studied along with them under the philosopher Isocrates.

The chief work of Ephorus was a history of the wars between the Greeks and Persians; in which, like Herodotus, he introduced the description of foreign and barbarous nations in the form of episodes. According to the scheme of Marx, the first book contained an account of the return of the Heraclidæ into the Peloponnesus, and the change of affairs consequent upon that event; the second was occupied with the state of the rest of Greece; and the third narrated the departure of the Greek colonies to Asia. In these three books he thus brought the history of Greece and Asia down to that period when they began to assume a peaceful aspect, probably a few years before the commencement of the Median war. After this introduction he proceeded to describe separately each country which subsequently became the scene of important transactions; in the fourth book Europe; in the fifth Asia and Africa; and in the sixth he probably gave an account of the nation of the Pelasgi. The seventh book contained the most ancient traditionary notices of Sicily, and probably all he could collect respecting the original inhabitants of Italy and the adjacent islands. The eighth book narrated the various changes of fortune to which those nations had been subject who in succession held the supreme command in Asia, namely, the Assyrians, Lydians, and Persians. The fragments which remain refer principally to the history of Crœsus. In the ninth book he described the origin, changes, and migrations of the Amazons, Scythians, and other nations who inhabited the coasts of the Pontus and those northern countries whence, through Thrace and Thessaly, he returned to Greece and its affairs. Then it was that Ephorus reached the period when, like every Greek historian, he imagined that the transactions of the whole world became centred in the causes and events of the Persian war; and then also he began to treat his subject with more copiousness, for we find that in his tenth book he had already brought down his history to the times of Miltiades, about 490 B.C. In his eighteenth book he had reached Dercyllidas, 399 B.C. In his twenty-fifth he had arrived at the battle of Mantinea, 362 B.C. We thus see that he must have employed seven or eight books in describing 37 years, whilst his last four or five books could contain the history of only 22 years. The part of the thirtieth book which gave an account of the sacred war was composed, not by Ephorus himself, but by his son Demophilus. At the conclusion of the war Ephorus took up the thread of the history, and continued it to the siege of Perinthus, 340 B.C. According to Diodorus Siculus, the whole period treated of was 750 years.

Ephraem Syrus.

For a more full description of the life of Ephorus, and a collection of the fragments of his history which have been preserved, the reader may consult *Ephori Fragmenta a Marxio*, Carlsuh, 1815; Creuzer, *Symbolik und Mythologie der alten Volker, besonders der Griechen*, Leipsic, 1819; Vossius *De Historicis Græcis*, Lugd. Bat. 1651; and Ulrici, *Charakteristik der antiken historiographie*, Berlin, 1833.

EPHRAEM SYRUS, or the Syrian, flourished in the fourth century of the Christian era, and acquired great renown among his contemporaries, and has since been esteemed one of the most celebrated fathers of the church. Of the events of his life but little is known, and what has been handed down to us is much lessened in value by an admixture of apochryphal stories. The following is a translation of a short memoir of Ephraem from a Syriac source. The original is found in a MS. of the fourteenth century, which is printed by Assemanni in the Roman edition of the works of this father. "The blessed Mor Ephraem was a Syrian by birth; his father was of Nisibis, his mother of the city Amida. His father was an idolatrous priest, and they lived in the time of Constantine Victor. His father expelled him from him because he was not obedient to his wicked will; he therefore went and lived with the holy Mor Jacob, the bishop of Nisibis, and led an entire life of godliness until the time of Jovian. He then left that place and came to the city Edessa, where he received the gift of the Holy Ghost, and abundantly supplied the church with the gifts and doctrine of the Spirit. After a time he went to the desert of Egypt, and from thence to Cæsarea of Cappadocia to Basil, and received from him the imposition of hands for the diaconate. He immediately returned to Edessa, and ended his life there in the year 684 (of the Greeks), on the ninth day of Haziron (June), that is, in the year 372 of the advent of our Lord." A much longer life also exists in Syriac, which gives however no more historical data which can be relied on. Ephraem, also, wrote a piece which is called his testament or will, and contains curious autobiographical matter, referring to his religious history and feelings.

But although the external facts of the life of Ephraem are few and perhaps doubtful, there is no question of the manner in which he impressed his genius and spirit upon his own age, or of the great value of the monuments of them which have descended to our own. His popularity and influence among the luxurious and refined people of Edessa were very great. He successfully combated the heresies of Bardesanes, the Gnostic philosopher; and

because that learned man had used poetical measures and music in instructing the people, this father cultivated the same arts, and succeeded in captivating his hearers to a high degree. It is a fact scarcely known till lately, even to the learned, although patent in Ephraem's Syriac remains, that he almost always wrote and preached in metre. It appears that he was ignorant of Greek, although it is by translations of his works into that language that they have been generally known. But his genuine remains are in three folio volumes, all the contents of which are in various metres, except some commentaries on the Old Testament. From the testament alluded to above, we quote a few lines, which will illustrate this peculiar feature of his literary character. In the original the verses are Heptasyllabic.

When I was but a little child,
Yet reposing on my mother's breast,
I saw as it were in a vision
What turned out to be truth;
A vine sprung forth from my tongue,
Which grew and touched the heaven;
It produced fruit without measure,
And branches almost innumerable;
The people gathered from it without stint,
Yet its clusters became more abundant.
These bunches of fruit were hymns,
And these branches were homilies;
God was the bestower of them,
Glory be to Him for his goodness!
He gave to me according to His pleasure,
From the house of His treasures.

The works of Ephraem have been published in several imperfect and translated forms, but the best edition is that of the Assemanni, published at Rome, 1732–43, 6 vols. folio, three in Syriac and three in Greek, with many learned appliances. See also *Select Metrical Hymns and Homilies*, and *The Repentance of Nineveh, a Metrical Oration*, translated by Dr Burgess. (H. B.)

EPHRAIM, the younger son of Joseph, who received the precedence over the elder by the blessing of Jacob. At the exodus from Egypt, the tribe of Ephraim, of which he was the founder, numbered 40,500, but in their wanderings the number was diminished by 8000. Their possessions in the very centre of Palestine included most of what was afterwards called Samaria. They were long jealous of the regal honours of Judah; but after the dismemberment of the tribes, their rivalry was merged in that subsisting between the two kingdoms.

EPHRAIM, a city in the wilderness of Judea, to which Jesus withdrew from the persecution which followed the miracle of raising Lazarus from the dead. It is placed by Eusebius eight Roman miles N. of Jerusalem. This would seem to make it the same with Ephraim mentioned in 2 Chron. xiii. 19 as one of the towns taken from Jeroboam by Abijah. It was also the name of a mountain or group of mountains in central Palestine, in the territory of the tribe of that name on or towards the borders of the land of Benjamin. The forest of Ephraim in which Absalom lost his life was in the country E. of Jordan, not far from Mahanaim.

EPHYDOR, in *Antiquity*, the keeper of the water-clock, or water hour-glass, in the Athenian courts of justice. The plaintiff and defendant in a suit were not permitted to speak after the glass had run out, and consequently they were careful to avoid unnecessary digressions.

EPI, a Greek prefix (ἐπι) signifying addition, applied to, on, upon, &c.

EPIBATÆ, in *Grecian Antiquity*, the name given to soldiers whose duty it was to fight on board ship. They corresponded almost exactly to the marines of modern naval warfare. They were employed more extensively by the Athenians than by the other maritime powers of ancient Greece. The number of epibatæ allotted to each trireme appears to have been originally ten; but the number was afterwards reduced to seven. They were commonly selected from among the Thetes or fourth class of the Athenian citizens. The term is sometimes found in Roman authors to denote the same class of soldiers, but the general phrase adopted by them is *milites classiarii*, or *socii navales*.

EPIC (ἐπικός, from ἔπος *a song* or *verse*), narrative; containing narration; rehearsing. An epic poem, otherwise termed *heroic*, has been well defined to be the poetical development, in narrative, of some great and interesting event, or series of events, sufficiently separate from what goes before or follows, to possess the character of a whole; having therefore a clear and distinct beginning, middle, and end; an action simple at first, leading into a complication of plot, and terminating in a natural and soothing solution. Among its accessaries are—the employment of supernatural agency, the introduction of episodes, formal addresses, invocations, and similes. None of these latter have any essential connection with epic poetry; and their introduction varies with the theme, the age, and the national associations of the poet.

The four greatest of epic poems are the *Iliad*, the *Æneid*, the *Jerusalem Delivered*, and the *Paradise Lost*.

EPICEDION (from ἐπι, and κῆδος, *funeral*), in Greek and Latin poetry, a funeral poem or dirge. At the obsequies of persons of distinction there were usually three similar marks of honour: the eulogy rehearsed at the *bustum* or funeral pile, and called *nenia;* the inscription on the tomb, *epitaphion;* and the poem delivered in the funeral ceremony, and called *epicedion*. There are two beautiful specimens of the latter in Virgil; that of Euryalus, and that of Pallas.

EPICENE (ἐπι, and κοινος *common*), in *Grammar*, a term applied to nouns which, under the same gender and termination, mark indifferently the male and female species.

EPICHARMUS (540-450 B.C.), a celebrated poet of the old comedy, was born in the island of Cos, where his father Elothales was a physician of the house of Asclepiads. According to Diogenes Laertius, he was brought to Sicily when only three months old; but it is more probable according to Suidas that he migrated thither of his own accord at a later period. After the destruction of Megara he removed to Syracuse, where at the court of Hiero he spent the remainder of his days. From his protracted residence in the island he is generally known in antiquity as a Sicilian (Hor. *Ep.* ii. 1. 58). Epicharmus studied philosophy under Pythagoras (for it is now generally admitted that Epicharmus the Pythagorean, and Epicharmus the father of the old comedy are identical), and the great rule of his philosophizing was to believe nothing rashly (Cic. *De Petit. Cons.* c. 10). It was only after his residence in Megara, the native soil of comedy, that he turned his attention to that branch of dramatic literature. His principal merit in this department seems to have consisted in the exclusion of that vulgar buffoonery which disgraced all previous comedies, and in the introduction of a regular plot in which the *comus* or band of revellers sustained the dialogue; and maxims drawn from the Pythagorean ethics were liberally interspersed. "The subjects of the plays of Epicharmus," says Müller (*Dorians*, iv. 7. 2) "were mostly mythological, *i.e.* parodies or travesties of mythology, nearly in the style of the satirical drama of Athens. Thus in the comedy of *Busiris* Hercules was represented in the most ludicrous light, as a voracious glutton; and he was again exhibited in the same character (with a mixture perhaps of satirical remarks on the luxury of the times), in the *Marriage of Hebe*, in which an astonishing number of dishes was mentioned. He also, like Aristophanes, handled political subjects, and invented comic characters like the later Athenian poets. The piece called *The Plunderings*, which described the devastation of Sicily in his time, had a political meaning; and this was perhaps also the case with *The Islands:*

at least it was mentioned in this play that Hieron had prevented Anaxilas from destroying Locri." Of his comedies, which are generally written in trochaic tetrameters, thirty-five titles and a few fragments are still extant. The excellence of his dramatic style is proved by the high estimation in which he is held by Plato.

EPICHEIROTONIA, in *Grecian Antiquity*, a voting by show of hands. It was ordained by Solon that a revision of the laws at Athens should take place annually, for the purpose of amending or repealing such as might be found unsuitable to the existing state of affairs. This was called ἐπιχειροτονία τῶν νομῶν, from the manner of giving suffrages on such occasions by holding up the hands. (See Potter's *Archæol. Græc.*, vol. i., p. 242.)

EPICLERUS, an Attic law term, denoting an only daughter and heiress, who was obliged to marry her next of kin. See EPIDICASIA.

EPICTETUS, a celebrated Stoic philosopher who flourished in the first century of the Christian era, was born at Hierapolis in Phrygia. The date of his birth is not precisely ascertained. He was the slave of Epaphroditus, one of Nero's freedmen and favourites, during the last years of that emperor's reign; but had obtained his freedom previous to the publication of the edict of Domitian which ordered the expulsion of the philosophers from Rome, and compelled him to retire to Nicopolis. From Spartian, it would seem that he afterwards returned to Rome, and was a favourite at the court of Hadrian; and from an expression of Themistius, it has been inferred that he was alive even in the age of the Antonines. It is more probable, however, that he died at Nicopolis; and Aulus Gellius speaks of him as dead previous to the accession of the first Antonine. Of the moral character of Epictetus many interesting illustrations have been handed down to us. The anecdote related of him by Origen shows him to have given early indications of remarkable fortitude and equanimity. When his master one day amused himself by twisting his leg, Epictetus mildly warned him that he would break it, and when it was actually broken by his violence, the youthful Stoic calmly remarked, "Did I not tell you that you would do so?" For a considerable part of his life he dwelt alone in a miserable hut without any furniture except a bed and a lamp; but afterwards, for the sake of a poor foundling he had taken home, he was induced to hire an attendant. During his meditations his lamp was one day stolen; but Epictetus calmly remarked, that if the thief came back he would "disappoint him, for instead of an iron lamp he would only find an earthen one." This earthen lamp was sold at his death for three thousand drachmæ. From his pupil Arrian, we learn that Epictetus studied philosophy at first under a Stoic teacher called Musonius Rufus; and it is from him also that we derive our knowledge of his doctrines. From the high tone which everywhere pervades his ethical system, some have been induced to believe that he was acquainted with Christianity. Whatever foundation there be for such a supposition, it is at least certain that in the maxims of Epictetus we find the nearest approach to Christian morality. Discarding altogether the physical speculations of Cleanthes, and purging his system from the unearthly and cynical elements of previous Stoicism—such as its repulsive doctrine in regard to suicide—he based all morality on the observance of the maxim, "bear and forbear;" and this rule he held ought to be observed, not in a spirit of proud self-sufficiency, but under the influence of a firm belief in the existence of a supreme moral governor, directing for benevolent purposes all the events of human life. Epictetus himself does not seem to have committed any of his principles to writing, although Suidas affirms that he wrote much which is now lost. Arrian, his most distinguished pupil, seems to have made a careful compilation of his discourses, and we still possess four books of his work on the philosophy of Epictetus, besides the *Encheiridion*, which contains, in short compass, his leading ethical principles. The best edition is that of Schweighäuser, *Epictetæ philosophiæ monumenta*, Gr. Lat. 6 vols. 8vo.

EPICUREAN PHILOSOPHY, the system of doctrine, canonical, physical, and ethical, taught by Epicurus, and maintained by his followers, who, from the name of their master, received that of Epicureans.

The first part of this threefold system regarded the canons or rules of judging. Disgusted with the subtleties and paradoxes of the Stoics, Epicurus endeavoured to introduce a more simple and natural method of judging, and, instead of artificial modes and scholastic distinctions, appealed to the common sense and natural perceptions of mankind as the ultimate basis of all reasoning. These he assumed as first principles, or rather as unerring guides; and by giving excessive latitude to an elementary definition, which, if properly guarded and restricted, might have served as the foundation of a rational system of logic, he was betrayed into errors and extravagances not less startling than those from which it had been his object to escape. Cicero has reproached him with an alleged unphilosophical contempt of logic; but this censure, when duly weighed, must be pronounced to be entirely without foundation. Epicurus, it is true, despised and even ridiculed the modes of reasoning by means of which the Stoics evolved the paradoxes in which they delighted; and he was neither acquainted with nor had any relish for those analytical investigations in which the members of that philosophical sect displayed so much unprofitable ingenuity. But, on the other hand, all the errors with which his system is easily chargeable, may be traced to the logical strictness with which he adhered, in all his reasonings, to the primary canon which he had laid down, and to the implicit faith which he was consequently led to repose in those sensible perceptions and intuitive judgments which, though in every case relatively true, are nevertheless in many cases absolutely and demonstrably false. Having, as he conceived, established a principle indisputably certain, he was prepared to admit, and, in point of fact, never suffered himself to doubt or to question any consequence, however startling, which might be logically deduced from it. His very errors, therefore, are the direct and necessary result of a rigid adherence to this principle, and of the precision with which he reasoned from the primary assumption to its consequences.

In the second or physical part of his system, Epicurus borrowed from Democritus and Leucippus the idea of the atoms or monads, which he regarded as the ultimate principles of all things. These atoms, however, which had no other properties than those of hardness and gravity, and which were, therefore, totally distinct from the gases of every kind that form so prominent a part of the physics and chemistry of the moderns, soon fell into discredit with philosophers; and, notwithstanding the poetical embellishments which the hypothesis received from the genius of Lucretius, it continued to be treated as a subject more fitted for ridicule than reason, until Gassendi endeavoured to revive and restore it, but without success. The efforts of this philosopher, however, can scarcely be considered as having proved altogether fruitless, since Leibnitz in his theory of monads, Boscovich in his principles of corpuscular attraction, and still more recently Dr Dalton in his theory of definite proportions, which has effected a complete revolution in the nomenclature of modern chemistry, have, each in succession, adopted modifications of the original hypothesis, and thus brought within the precincts of science a doctrine once regarded as amongst the wildest extravagances of ancient philosophy. In fact, the atomic theory of modern times is founded upon the same general principle with the hypothesis promulgated by Democritus, taught by Leucip-

Epicurean Philosophy.

pus, and afterwards adopted by Epicurus; namely, that matter, so far from being infinitely divisible, is resolvable by division, decomposition, or analysis, into certain ultimate or primordial elements or atoms, which, again, enter synthetically, in certain definite proportions, into the constitution or composition of all things. And thus it is that the grand cycle of decay and reproduction, observable in the operations and changes which take place in the material world, may also be detected in the history of philosophical systems: they rise, decline, disappear, and are reproduced by the silent working of causes too remote to be discovered or appreciated by us; they have their various phases and occultations, even whilst they remain within the sphere of our observation; and when they altogether disappear from our view, and seem to be for ever lost, it is only to return, after having rounded their apogee, and to present nearly the same aspect as before.

With regard to the third or ethical part of this system, morality, according to Epicurus, is entirely founded upon utility. Man is placed upon earth to seek or pursue his own happiness or good, and he finds it only in a calm and tranquil life. The sage is ever upon his guard against the passions which might disturb his peace. Physical pleasure consists in the satisfaction of our natural wants; but the less trouble we take to ensure this satisfaction, the fewer privations we will be exposed to, and the greater will be our immunity from reverses of fortune. To abstain in order to enjoy, was accordingly the grand maxim of this philosopher. The happiness of individuals depends upon, and forms part of, the general happiness, from which, therefore, it can never be separated. This is his leading principle; and hence the essence of his ethical system consists in inculcating the *maxima felicitas*, or the greatest happiness of the greatest number. It has, indeed, been vulgarly alleged that Epicurus made the supreme good to consist in pleasure; and many persons persist in thus representing his doctrine, without giving themselves the trouble to inquire what he understood by pleasure; a term which, as he applied it, differs in no degree from the wisdom of the Stoics, and the *maxima felicitas* of the modern school of Utilitarians, founded by Bentham, the great restorer of the Epicurean ethical philosophy. In the nomenclature of this system, whatever contributes to the happiness and well-being of man as a member of society, is denominated pleasure; nor, as the happiness of individuals is made to depend upon, and declared to be inseparable from the general happiness, can the true meaning of the term be mistaken or misapprehended by any honest and intelligent inquirer. But those false Epicureans, who limited the import of the word to mere sensual indulgence, and reasoned as if Epicurus himself had recognised this acceptation, did great injury to the sect by thus bringing it into unmerited discredit and odium. We accordingly find that they were banished from Rome in the time of the republic, and also, at different intervals, from a number of other cities. But the school always subsisted at Athens, where it remained in the time of Lucian; and his contemporary, Numenius, remarks, with an evident feeling of regret, that the Epicureans had preserved in all its purity, the doctrine of their master, whilst that of Plato had been greatly altered and corrupted. The Stoics appropriated several of the maxims, and adopted the most remarkable apophthegms of Epicurus, which are expressed, with much spirit, in a brief, sententious style; and the principal charm of Seneca's letters to Lucilius consists in the freedom and extent to which he has borrowed from the same source.

It is very difficult to discover the real opinion of Epicurus respecting the divinity. Cicero asserts that the philosopher spoke of the Supreme Being in terms the most sublime, and that he recommended piety to his disciples. It may, no doubt, be alleged that this was done in order to conform to the popular belief, and that no safe conclusion can be drawn as to the opinion really entertained by the philosopher, from mere generalities, or a convenient and safe recommendation. But, on the other hand, in his letter to Menecius, Epicurus expresses himself thus: "The gods are not such as the vulgar believe; and the impious man is not he who rejects the gods of the multitude, but he who attributes to the gods the opinions of the multitude." These expressions, if they had been known, would have been sufficient to ensure to their author the honours of persecution. But, whilst it is evident that Epicurus was not actuated by mere prudence in making the belief of a God one of the principal dogmas of his philosophy, it must at the same time be admitted that his other opinions respecting the gods rendered this belief useless. For he regarded them as beings perfectly happy, impassible, and in no degree concerned about or disposed to intermeddle with human affairs—as alike indifferent to and incapable of being affected by the good or evil of this world; and thus destroyed at once a providence, and the hope of future recompense or punishment. To this opinion, certainly one of the most discouraging and disastrous which can be maintained or promulgated, may be mainly ascribed the charge of atheism which was early preferred, and often subsequently reiterated, against this amiable and virtuous philosopher, whose life was as remarkable for its moral purity as those of some of his pretended followers were for their dissoluteness and profligacy.

Epicurus.

EPICURUS, one of the most celebrated philosophers of antiquity, and founder of the sect which bears his name, was descended from the family of the Philaides, who traced their lineage from Philæus, grandson of Ajax. His father, Neocles, resided in Gargettium, a borough of Attica, and is hence sometimes simply styled *the Gargettian;* but finding himself ill provided in point of fortune, he emigrated along with an Athenian colony to Samos, B.C. 352. As Diogenes Laertius fixes the birth of Epicurus in the year 341 B.C., it may be regarded as certain that the philosopher was born at Samos, and not at Gargettium, as some suppose. In his early youth he is said to have followed his mother Charestrata, who appears to have been an itinerant sorceress, reading the formularies of exorcism and expiation, whilst she performed the ceremonies usual on such occasions; but as he advanced in years he assisted his father in keeping a school, which the latter had established at Samos. At the age of fourteen Epicurus began to devote himself to philosophy, impelled to this study by his inability to solve his doubts in regard to the chaos of Hesiod. He at first attended Pamphilus, one of the disciples of Plato, and Nausiphanes, a philosopher of the school of Democritus, but not the disciple of Pyrrho, as Diogenes Laertius affirms, Pyrrho having been the contemporary of Epicurus. But the lessons he received from these teachers did not satisfy his mind; and having applied himself to the study of the writings of Democritus, he made great progress in philosophy, and soon thought himself in a condition to form a new sect. At the age of eighteen he proceeded to Athens; but during the troubles which ensued after the death of Alexander, he repaired to Colophon, in Ionia, whence he afterwards went to Mitylene and Lampsacus. It was at these latter places that he began to profess his new principles of philosophy. Having attracted a great number of disciples, amongst whom were the three brothers Neocles, Charidemus, and Aristobulus, he returned with them to Athens, B.C. 309; and having there purchased a garden for eighty minæ, he immediately commenced teaching his philosophy. In imitation of the Pythagoreans, his disciples formed a community by themselves. Epicurus did not, however, recommend or encourage a community of goods, which he considered as calculated to excite distrust; but each paid a portion of the general expense, which was in itself inconsiderable, as they were content with the simplest fare. The most per-

fect union reigned amongst them, and indeed subsisted undisturbed long after the death of Epicurus. Cicero says that the Epicureans of his time still lived in common, and in the best understanding with one another. Women were even admitted into this society; and amongst its most celebrated female disciples are mentioned Leontium, an Athenian courtezan, and Themista, wife of Leontius of Lampsacus. As Epicurus never taught in public, the sect was little celebrated during his lifetime; but after his death, when his writings became generally known, the doctrine therein taught was warmly attacked by the Stoics, who did not blush even to have recourse to the most atrocious calumnies. Diotimus the Stoic went so far as to fabricate, in the name of Epicurus, fifty letters addressed to courtezans, in which the philosopher is made to express himself in the most obscene manner; but Chrysippus himself bears testimony to the blameless conduct and manners of Epicurus; and although the latter alleged that this was not the result of philosophy, but attributable solely to coldness and insensibility of temperament, it is certain that his life was wholly free from those vices with which his enemies have reproached him. For a short account of the system taught by this philosopher, see EPICUREAN PHILOSOPHY. Epicurus died of the stone, B.C. 270, in the seventy-second year of his age. He was never married, and kept himself entirely aloof from the political parties of the state. By his will, which Diogenes Laertius has preserved, he bequeathed his garden and a house which he had at Melitus to his successor Hermachus, and to those who should after him be at the head of his school, in order that his followers might assemble on the spot where his system was first taught. His memory was held in veneration by his disciples, and the anniversary of his birth was celebrated as a festival; they had his portrait engraved on their rings and on their cups, as well as placed in their chambers; and they never spoke of him but with the greatest respect. Epicurus is said to have been a most voluminous author. Almost all his works, however, have perished; but in the four letters preserved by Diogenes, we have a tolerably complete outline of his system. Parts of his work *On Nature* have been found among the Greek MSS. discovered at Herculaneum. These were published by Corsini, and have been reprinted separately by Orelli. No one has better developed the philosophical system of Epicurus than Gassendi in his *Syntagma de Vita et Moribus Epicuri*, lib. viii. Lyons, 1647. See also Durondel, *Vie d'Epicure*, Paris, 1679; Coutures, *La Morale d'Epicure*, Paris, 1685; *Apologie pour Epicure*, and *Discours sur Epicure*, Paris, 1651 and 1684, 12mo; Warnekros, *Apologie und Leben Epicurs*, Greifswald, 1795; and Steinhart in Ersch and Gruber's *Allgem. Encyclop.* xxxv., p. 459.

EPICYCLE, in the *Ancient Astronomy*, a little circle whose centre is in the circumference of a greater circle; or a small orb or sphere, which, being fixed in the deferent of a planet, is carried along with it; and yet, by its own peculiar motion, carries the planet fastened to it round its proper centre. It was by means of epicycles that Ptolemy and his followers solved the various phenomena of the planets, but more especially their stations and retrogradations. See ASTRONOMY, vol. iv. p. 53.

EPICYCLOID, in *Geometry*, a curve generated by a point in the circumference of a circle which rolls along the circumference of another circle, either on the convex or the concave side of its circumference. When generated in the latter way, the curve is sometimes called a *hypocycloid*. See CONIC SECTIONS, part ii., prop. xxv., xxvi., xxvii., xxviii.

If a moveable circle roll along the concave circumference of a fixed circle of twice its diameter, any given point in the circumference of the smaller circle will describe a straight line, which is the diameter of the larger circle. This beautiful property has been applied in mechanics to the production of a rectilineal alternating motion from a continued circular motion. See MECHANICS.

EPIDAMNUS (which afterwards came to be called DYRRHACHIUM), a city of Illyricum, on the shore of the Ionian Sea. It was founded by a joint colony of Corcyreans and Corinthians towards the close of the seventh century B.C., and from its admirable position, and the fertility of the surrounding country, it soon rose into very considerable importance. The original form of government was an oligarchy, the dissolution of which by the increasing power of the democrats was one of the causes that embroiled the original founders of the city, and contributed to bring about the Peloponnesian war. In the course of this struggle Epidamnus soon sank into a secondary position, and ultimately disappeared altogether in the contest till, in 312 B.C., it was seized by Glaucias king of the Illyrians. About the close of the war it was attacked by pirates, who were twice driven back—on the second occasion by the timely arrival of assistance from Rome. As the name Epidamnus sounded to Roman ears like an evil omen, the inhabitants, in compliment to their deliverers, changed its name into Dyrrhachium, from the rugged nature of the adjoining sea-coast. In the later history of the Roman republic Dyrrhachium became famous as the place where Pompey made the last successful resistance to the rising fortunes of Cæsar, who was at length compelled to retire from his position and transfer the theatre of war to another seat. At the end of the struggle between Antony and Augustus, Dyrrhachium fell into the hands of the latter, and was by him made over to a colony of his veteran troops. Under the Lower Empire it became the capital of Epirus Nova, and in 1081 was stormed by the Norman Guiscard, who in that year defeated the Greeks under their emperor Alexius. On the site of the ancient town stands the modern Durazzo.

EPIDAURUS, in *Ancient Geography*, a maritime town on the eastern coast of Argolis, renowned as the principal seat in Greece of the worship of Æsculapius. It stood on a small peninsula which projected into the sea, and had originally a small portion of territory attached to it, which was severed from the rest of Argolis by a mountain range, and from a remote period was noted for its fertility. Epidaurus was at first an independent state, and its proximity to Athens and the islands of the Saronic gulf, the advantages of its position in a commercial point of view, and the sacredness attaching to it from its temple of Æsculapius, soon made it a place of very considerable importance. It is said to have been founded by a colony of Carians; an idea borne out by the primitive name of the city, which was Epicarus. These Carians gave way before the Ionians, who in their turn were driven out by the Dorians under Deiphontes. Under the descendants of this prince Epidaurus attained great prosperity, and began to send out colonies, the chief of which, Ægina, speedily outstripped the mother city in wealth and power. To the monarchical form of government which Epidaurus inherited from Deiphontes an oligarchical succeeded, and, as in many other of the Greek states, the oligarchy degenerated into a despotism. When Procles, the last tyrant of Epidaurus, fell into the power of Periander of Corinth, the oligarchy was restored and maintained with the aid of Sparta. How the administration of affairs was actually carried out cannot now be ascertained. The only magistrates we read of are the artynæ, who presided over a council consisting of 180 members. The lower classes of the population, who tilled the soil for their Dorian masters in the city, were called *konipodes* or *dusty-feet*. When or from what causes Epidaurus declined from its great prosperity is not known; but in the time of the Romans hardly anything of it remained except the great temple of Æsculapius. Not far from the site of the old town stands the modern village of Pidhavro, a corruption of the ancient Epidaurus. The temple of

Æsculapius was one of the most celebrated of all the sacred places in Greece. It was distant five miles from the city, and stood in the midst of a lawn which was nearly a mile in circumference. The wall which inclosed this lawn is still partly visible. A festival in honour of the patron god was celebrated in the adjoining grove every fourth year, nine days after the Isthmian games at Corinth. Some remains of the great temple may still be seen; and a theatre believed to have been connected with it is the most perfect ruin of that kind in the whole of Southern Greece. From the immense crowds of sick persons who flocked from all parts of Greece to propitiate Æsculapius, the temple soon acquired vast wealth. The report of these riches tempted the cupidity of Sulla, who had shortly before robbed the temples at Delphi and Olympia. The walls of the building itself were hung round with the votive tablets of the patients who had recovered from their diseases through the intervention as they supposed of the son of Apollo.

There were two other ancient cities of this name; one a maritime town of Illyricum, now called Ragusa Vecchia; the other a maritime town of Laconia, whose ruins are still visible at Monemvasia.

EPIDEMIC, an epithet applied to any disease which occasionally prevails in a country or district, and gradually disappears, but which is in danger of periodically returning. See ENDEMIC.

EPIDICASIA, in ancient Athens, an action for an inheritance. Daughters inheriting their parents' estate were obliged to marry their nearest relation; and hence it frequently happened that persons of the same family went to law with one another, each claiming to be more nearly allied to the heiress than the rest. The heiress thus contended for was called ἐπίδικος. So stringent was this law, that even after marriage her husband might be compelled to give her up to a man with a nearer claim. It was also not uncommon for men to put away their wives in order to marry heiresses.

EPIGONI, the sons and descendants of the Grecian heroes who were killed in the first Theban war. The war of the Epigoni is famous in ancient history. It was undertaken ten years after the first Theban war. The sons of those who had perished in that contest resolved to avenge the death of their fathers, and marched against Thebes, under the command of Thersander, or, according to others, of Alcmæon the son of Amphiaraus, about 1307 years B.C. The Argives were assisted by the Corinthians and the people of Messenia, Arcadia, and Megara. The Thebans had engaged all their neighbours in their quarrel, as in one common cause. The two hostile armies met on the banks of the Glissas, and a battle ensued. The combat was obstinate and bloody; but victory declared for the Epigoni, and some of the Thebans fled to Illyricum with Leodamas their general, whilst others retired into Thebes, where they were soon afterwards besieged and forced to surrender. In this war Ægialeus was the only person of note who was killed; whereas in the former war his father Adrastus had been the only one of the seven who escaped alive. This whole war, as Pausanias observes, was written in verse; and Callinus, who quotes some of the verses, ascribes them to Homer—an opinion which has been adopted by many writers. "For my part," continues the geographer, "I own that, next to the Iliad and Odyssey of Homer, I have never seen a finer poem." The names of the Epigoni are not uniformly the same in the various traditions connected with them; but the most received accounts give them as follows:—Ægialeus, Alcmæon, Diomede, Euryalus, Promachus, Sthenelus, and Thersander. The *Epigoniad* of Wilkie is a modern poetical celebration of the same story. The descendants of the veteran Macedonians, who served under Alexander the Great, and who had children by Asiatic women, were also called Epigoni.

EPIGRAM (ἐπι, and γράμμα, *a writing*), a short poem, treating only of one thing, and ending with some lively, ingenious, and natural thought. The excellence of epigram depends on conciseness and point. The Latins were the first to impart to the epigram the character of caustic piquancy, which constitutes its principal charm. Of their professed epigrammatists the best are Martial and Catullus; both of whom afford many specimens of good attempts, with a still greater number of failures. In both also licence of thought and expression degenerate so often into downright licentiousness that a modern reader hardly finds in the wit a compensation for the obscenity. Neither in France nor in England is there any other who has achieved renown solely as an epigrammatist. In the former country the best epigrams are those of Marot, J. B. Rousseau, Racine, Piron, Lebrun, and Chénier. The following is an epigram of Lebrun on a lady who affected wit and coquetry:—

> Cloé, belle et poète, a deux petits travers;
> Elle fait son visage et ne fait pas ses vers.

One of the best English epigrammatists is Pope. Some of his compositions in this vein are very happy. In a company where the members were amusing themselves with making rhymes, Pope asked Lord Chesterfield for the loan of his pencil, and wrote—

> Accept a miracle; instead of wit,
> See two dull lines by Stanhope's pencil writ.

The next is on a person who made long epitaphs.

> Friend, for your epitaphs I'm grieved;
> Where still so much is said,
> One half will never be believed,
> The other never read.

It happens curiously enough that the best of the English epigrammatists have also for the most part distinguished themselves as lyrists. See POETRY.

EPILEPSY, known also by the names of the *morbus comitialis*, *morbus sacer*, and *falling sickness*, is a convulsive disease which attacks suddenly at more or less regular intervals. Three almost distinct forms of the disease are met with. In the mildest form only stupor occurs, the person losing consciousness, but continuing to walk without knowing where he is going. In the next form the person is suddenly seized with a sick feeling or faint, and drops off his chair or falls down, groaning slightly, being insensible for the moment, and the whole body becomes bedewed with a cold clammy perspiration. These two forms, however, if the disease goes on, pass into the more severe form, when the person on being affected suddenly utters an unearthly scream or yell, and falls down quite insensible, the body and extremities becoming quite rigid. Quivering of the voluntary muscles instantly follows, which increases to regular convulsive motions, twitching the body and limbs into various positions. The eyes usually remain open, the face is much distorted, foam gathers in the mouth, and is often tinged with blood from the tongue being injured by the teeth. The breathing is more or less laborious, and very generally the lips are blown out at each expiration. The pulse, at first quick and feeble, becomes slow and languid. As the spasms abate slight consciousness returns, on which the person usually falls into a sleep which endures from half an hour to several hours, and from this he awakes weak and languid. These fits for the most part exhibit a tendency to periodic recurrence. In certain rare cases epilepsy, though recurring at intervals, does not appear to injure the intellect; but in the great majority of cases the mental faculties become more and more impaired as the disease progresses, and the person at last falls into a state of perfect idiocy, if not cut off previously during a fit or by its terminating in apoplexy or paralysis. Often, however, a violent fit of insanity follows an epileptic fit. The pathology of the disease is very obscure, for as yet no relation whatever has been traced between the existence of any known lesion of the brain and the epileptic fits. True it is that in most epileptics the brain is found in a more or less

diseased state; but the same morbid changes occur in others who have had no epileptic fits; and in some who were subject to epileptic fits for years no organic changes have been discovered in the brain. Epilepsy is usually considered as being divisible into two species—one depending on some primary affection of the brain; the other as a sympathetic disease depending on some diseased state of the stomach, liver, kidney, or other organ, and affecting the brain by a kind of reflex action. In a disease the nature of which is so little understood, it is not to be expected that the medical treatment is in a satisfactory state. Accordingly this disease has chiefly been treated by empirical remedies which now and then succeed in removing the fits; or rather the malady disappears while the person is undergoing a course of treatment, which gets credit for the cure. Instead of enumerating these, a few directions for the management of a person in a fit seem more appropriate to this notice. A person liable to epileptic fits should never be left alone, or allowed to go out riding, driving, or boating. He should avoid all excitement of mind and body, keep away from crowded places or streets, live moderately, and avoid stimulants. When seized with a fit, he should be supported by his attendant, and be laid gently down on the ground or floor, his neckcloth removed, and his head supported. No attempt should be made to administer fluids of any kind; but if the tongue seems to be in danger from the convulsive motions of the mouth, a cork or piece of wood may be inserted between the jaws and held there. When the fit is over, it is very desirable to allow the person to enjoy uninterruptedly the short sleep which follows, if in a place where this can be done. (J. S—K.)

EPILOGUE, in *Oratory*, the conclusion of a discourse in which the principal matters are recapitulated.

EPILOGUE, in the *Drama*, a speech or short poem addressed to the audience by one of the actors after the conclusion of the play, and usually containing reflections on some incidents in the play.

EPIMENIDES, the Cretan poet and prophet, was born at Phaestus, or according to others at Gnossus, about 660 B.C. His early life is enveloped in fable. When keeping his father's sheep one day, he is said to have retired into a cave where he fell into a profound sleep which lasted fifty-seven years. Returning home to the altered abodes of his family, he was hailed as the especial favourite of the gods, and venerated as the possessor of superhuman wisdom. He was invited by Solon to Athens, (about B.C. 596), in order to give the sanction of his sacred presence to the purification of the city previous to the promulgation of the political code of the great lawgiver. Having accomplished the desired lustration by the performance of certain religious rites, Epimenides was loaded by the Athenians with wealth and honours. He refused, however, to accept their gifts, contenting himself with a branch of the sacred olive, and the exaction of a promise of perpetual friendship between Athens and Gnossus. The death of Epimenides is said to have taken place in Crete, although Sparta boasted of possessing his tomb, and doubtless he may have travelled into many different countries, if (as one tradition runs) he attained the age of nearly 300 years. He wrote a poem on the Argonautic expedition, and several other works; but these, with a variety of spurious treatises attributed to him in ancient times, are now entirely lost. Epimenides is supposed to be the Cretan prophet to whom St Paul alludes in his Epistle to Titus (i. 12).

EPIMETHEUS (*i.e. afterthought*), brother of Prometheus. See PROMETHEUS.

EPINAL, a town of France, capital of the department of Vosges, situated on both sides of the Moselle, at the foot of the Vosges chain of mountains; 224 miles E. by S. of Paris. Pop. (1851) 10,183. The town is clean, and tolerably well built. It was formerly fortified, and has still remains of its ancient castle. Among its finest buildings are the barracks, the hotel of the prefecture, the Gothic parish church, and the theatre. It has also a communal college, public library of 20,000 vols., museum of paintings and antiquities, chamber of commerce, orphan asylum, hospital, and schools of design and music. Manufactures—embroidery, lace, linens, hosiery, earthenware, leather, paper, and chemical products. The vicinity abounds in agreeable promenades.

EPIPHANIUS, SAINT, a celebrated father of the church, was born in the beginning of the fourth century at Besanduca, a village of Palestine, near Eleutheropolis. He is said to have been of Jewish extraction. In his youth he resided in Egypt, where, under the Gnostics, he began an ascetic course of life; and on his return to Palestine he became a zealous disciple of the patriarch Hilarion, and eventually the president of a monastery which he founded near his native place. About A.D. 368, he was nominated bishop of Salamis, the metropolis of Cyprus—an office which he held till his death (A.D. 402). The latter part of his life was spent chiefly in carrying on a series of contests with Origen and his disciples. The first of those whom he attacked was John, bishop of Jerusalem, whom he denounced from his own pulpit; and afterwards, instigated by Theophilus, bishop of Alexandria, he proceeded so far as to summon a council of Cyprian bishops and condemn the errors of Origen. His next blow was aimed at Chrysostom, the patriarch of Constantinople, and a pretext was found in the shelter which he had given to four Nitrian monks whom Theophilus had expelled on the charge of Origenism. Finding himself baffled by the authority of Chrysostom, Epiphanius endeavoured to subvert his influence at the court; but having presumptuously announced to the Empress Eudoxia that her son, who was then ill, would die unless she ceased to favour the friends of Origen, he was immediately dismissed, and died on the passage home to Cyprus. At his parting interview with Chrysostom, he is said to have expressed the hope that that patriarch "would not die a bishop;" and Chrysostom, in retaliation, uttered a wish that "he would never get back in safety to his own country." Whether uttered by these two individuals or not, both of these malevolent wishes were literally accomplished. The principal works of Epiphanius are his *Panarion*, or treatise on heresies, of which he also wrote an abridgment; his *Ancoratus*, or discourse on the faith; and his treatise on the weights and measures of the Jews. These, with *Two Epistles* to John of Jerusalem and Jerome are his only genuine remains. The best edition of his works is that of the Jesuit Petavius, 2 vols. fol., Paris, 1622. In allusion to his knowledge of Hebrew, Syriac, Egyptian, Greek, and Latin, Jerome styles Epiphanius *Pentaglottos* or Five-tongued; but if his knowledge of languages was really so extensive, it is certain that he was utterly destitute of critical and logical power. His early asceticism seems to have imbued him with a love of the marvellous; and his religious zeal served only to increase his credulity, so that many of the most absurd legends in the early church have received the sanction of his authority. His works are, in fact, chiefly valuable from the quotations which they embody.

EPIPHANY (ἐπιφάνεια, *appearance, manifestation*), a Christian festival celebrated on the sixth of January, the twelfth day after Christmas, in commemoration of the appearance of our Saviour to the magi or wise men of the East, who came to adore him with presents; or, according to others, to commemorate the appearance of the star to the magi, or the manifestation of Christ to the Gentiles. Jerome and Chrysostom take the Epiphany to be the day of our Saviour's baptism, when a voice from heaven declared: "This is my beloved Son, in whom I am well pleased." The Greek fathers use the word for the appearance of Christ in the world; and in this sense it is used by St Paul, 2 Tim. i. 10.

EPIPHYTES (ἐπι and φυτόν *a plant*), plants growing

upon other vegetables, but which do not, like the parasites, derive nourishment from the plants to which they attach themselves. Many of the Orchidaceæ are of this class, and subsist entirely on air.

EPIRUS, in *Ancient Geography*, was the name given to that part of Northern Greece extending from the Acroceraunian promontory on the N., to the Ambracian Gulf on the S., and having the Ionian Sea on the W., and the chain of Pindus on the E. The word Ἤπειρος signifies mainland, and was the name originally given to the whole of the western coast of Greece, from the Acroceraunian promontory to the Corinthian Gulf, in contradistinction to Corcyra and the other islands along the coast. The country is wild and mountainous, and has more of a pastoral than an agricultural character. It was celebrated for its fine horses and cattle. The valleys, though numerous, are not extensive, and the produce of corn was insufficient for the wants of the people. The country was inhabited by various tribes, which were not regarded by the Greeks themselves as belonging to the Hellenic race. According to Theopompus, who lived in the fourth century B.C., the Epirots consisted of fourteen different and independent tribes, the principal of which were the Chaones, Thesproti, and the Molossi. The Chaones, who are said to have at one time ruled over the whole country, inhabited that part of it N. of the Thyamis; S. of which lay the territory of the Thesproti, which contained the town of Dodona, famous for its oracle and temple of Jupiter. The Molossians, who subsequently became the rulers of Epirus, originally inhabited a narrow strip of land extending northward from the Ambracian Gulf. It is not clearly ascertained who the original inhabitants of Epirus were, but it is most probable that they were of Pelasgic origin. Attempts have been made to identify the Chaonians with the Chones who dwelt in Italy on the shores of the Tarentine Gulf. Some names of places are also common to both countries, as the river Acheron and the city Pandosia. Aristotle places in Epirus the original home of the Hellenes, from whom Hellas ultimately took its name; but he does so in disregard of the opinion prevalent among his countrymen, that Thessaly was the native seat of that people. In any case Epirus, despite its distance from the principal centres of Greek thought and action, exercised even at an early period considerable influence upon Greece,—an influence attested, among other things, by the high esteem in which the responses of the Dodonean Grove were held. One of the earliest and most flourishing of the Greek colonies in Epirus was Ambracia, situated on the gulf called after that city. It was settled by the Corinthians. (See AMBRACIA.) The happy results of the experiment appear to have tempted others of the Greek states to follow the example; and Elæa, Buchetia, and other places, bear witness to the successful enterprise of the people of Elis.

The kings of Epirus claimed to be descended from Pyrrhus, son of Achilles, who settled in this country after the taking of Troy, and transmitted his kingdom to Molossus, his son by Andromache; but the early history of the kings of the Molossi is involved in much obscurity. Admetus sat on the throne of Epirus 480 B.C., at the time of the invasion of Greece by the Persians, and he remained neutral till their defeat, when he solicited an alliance with the Athenians. This was refused chiefly through the persuasion of Themistocles; yet Admetus was generous enough so forget this circumstance when Themistocles was banished, 471 B.C., by his ungrateful countrymen, and received him with every mark of respect and esteem.

Admetus was succeeded about 429 B.C. by his son Tharymbas or Arymbas I., who was at that time so young that he was placed, by a decree of the people, under the guardianship of Sabylinthus, prince of Atintania. He seems to have been a wise and prudent monarch, who attempted to introduce a regular form of government among a wild and a lawless people. Alcetas is the next king of Epirus mentioned in history, and he reigned about 385 B.C. Being driven from his throne by his subjects, he fled to Syracuse, but with the assistance of Dionysius was soon afterwards re-established. His son Neoptolemus reigned but a short time, and left the crown to his brother Arymbas II. about 360 B.C., who encouraged literature and the arts, governing his kingdom with prudence, equity, and moderation. It was to him that Xenocrates of Chalcedon dedicated the four books which he had composed on the art of governing. This prince educated with the greatest care the children of his brother. He married Troas, one of his nieces, and gave the other, Olympias, in marriage to Philip of Macedon, who had by her Alexander the Great. On his death, 342 B.C., he was succeeded by his nephew Alexander, brother of Olympias. This prince was put in possession of the throne of his uncle by the aid of his brother-in-law Philip, who afterwards gave him in marriage his daughter Cleopatra. It was at the celebration of these nuptials at Edessa that the king of Macedonia was assassinated.

Alexander was the first prince who raised the character and reputation of his country amongst foreign nations. Having been applied to by the Tarentines for assistance against the Samnites and Lucanians, he passed into Italy with a considerable force, made a descent (332 B.C.) at Pæstum, a city near the mouth of the river Silarus, and reduced under his dominion several cities of the Lucani and Brutii. In his second attack upon Italy he was surrounded by the enemy, defeated, and slain, near the city Pandosia, in the territory of the Brutii.

Œacides, the son of Arymbas II., succeeded to Alexander, and espoused the cause of Olympias against Cassander; but his soldiers, having mutinied, dethroned him, though he was in a short time reinstated. He was killed the same year, 313 B.C., in a battle against Philip, brother of Cassander. This prince had by his wife Phthia, the celebrated Pyrrhus, and two daughters, Deidamia and Troas, of whom the former married Demetrius Poliorcetes. His brother Alcetas, who succeeded him, continued the war with Cassander till he was defeated, and his dominions were overrun by the enemy. He was afterwards put to death by his rebellious subjects, 295 B.C. The name of Pyrrhus, who now ascended the throne, sheds a lustre on the annals of Epirus, and gives to its history an importance which it would never have otherwise possessed; but for a detailed account of his life we must refer to the article PYRRHUS.

Alexander, in 272 B.C., succeeded his father Pyrrhus, when he attempted to seize on Macedonia. He defeated Antigonus Gonatas, but was himself shortly afterwards driven from his kingdom by Demetrius, son of that prince. He recovered it, however, and spent the rest of his reign in peace. At the expiration of two other insignificant reigns, the family of Pyrrhus became extinct, upon which the inhabitants of Epirus changed the form of their government, electing annually a prætor in a general assembly of the nation held at Passaron, a city of the Molossi. Epirus imprudently espoused the cause of Perseus in his war against the Romans, when he was defeated and taken prisoner, 168 B.C.; and it was exposed to the unrelenting fury of the Romans, who destroyed 70 towns, and carried away to slavery 150,000 of the inhabitants. It never recovered from this fatal blow. At the dissolution of the Achæan league, 146 B.C., this country became part of the province of Macedonia under the name of Vetus Epirus, in order to distinguish it from Nova Epirus, which lay to the east.

On the division of the empire it became the inheritance of the emperors of the East, and remained under them until the taking of Constantinople by the Latins, in 1204, when Michel Comnenes seized on Ætolia and Epirus. On the death of Michel, in 1216, these countries fell into the hands of his brother Theodore. Charles, the nephew of Theo-

dore, and the last prince of his family, having died without legitimate heirs, Epirus and Acarnania were left to his natural children. Amurath II. stripped them of this inheritance. In 1443, Scanderbeg, king of Albania, made himself master of a considerable part of Epirus. But on his death it fell into the power of the Venetians, from whom it passed to the Turks, in whose possession it still remains, and forms part of Albania.

EPISCOPACY, that form of church government in which diocesan bishops are established, as distinct from and superior to priests or presbyters. From a very early period the ministers of religion have been distinguished into different orders, and it has been much controverted whether the distinction be of divine or human right, whether it was settled in the apostolic age, or only adopted afterwards. (See Bishop.) This controversy commenced soon after the Reformation, and has been agitated with great warmth between the Episcopalians on the one side, and the Presbyterians and Independents on the other. Amongst the Protestants churches abroad, those which were reformed by Luther and his associates were in general episcopal; whilst such as follow the doctrines of Calvin have for the most part dispensed with the order of bishops, as being either unnecessary or unattainable. In England, however, the controversy has been considered as of greater importance than on the Continent; for it has there been strenuously maintained by one party that the episcopal order is essential to the constitution of the church; and by the others, that it is a pernicious encroachment on the rights of Christians, for which there is no warrant or authority in Scripture. Though the question has for some time lain almost dormant, and though we have no desire to revive it, yet as a work of this kind might perhaps be deemed defective, did it contain no account whatever of a controversy which has employed some of the ablest writers of the past and present times, we shall give a fair though short view of the chief arguments by which the advocates of each contending party have endeavoured to support their own cause, leaving it to our readers to judge where the truth lies. See Independents and Presbyterians.

The Independent maintains, that under the gospel dispensation there is nothing which bears the smallest resemblance to an exclusive priesthood; that Christ and his apostles constituted no permanent order of ministers in the church; but that any man who has a firm belief in revelation, a principle of sincere and unaffected piety, a capacity for leading devotion and communicating instruction, and a serious inclination to engage in the important employment of promoting the everlasting salvation of mankind, is in all respects a regular minister of the New Testament, especially if he have an invitation to the pastoral office from some particular society of professing Christians.

Against this scheme, which supposes the rights and privileges of all Christian men to be equal, and which acknowledges no authority in the church excepting that which is derived from election by its members, the Protestant Episcopalian argues in the following manner: He admits, as an undoubted truth, that Christ gave to none of his followers authority or jurisdiction of such a nature as could interfere with the rights and duties of the civil magistrate; that he never conferred upon them what he disclaimed for himself, when, before Pilate, he declared that his kingdom was not of this world. He maintains, however, that Christ did confer upon his immediate followers, and does still confer upon their successors in the ministry, authority and jurisdiction of a specific nature over other Christians; and that neither during our Saviour's abode upon earth, nor during the period of the government of the church by apostles, nor in the age immediately succeeding these, did there exist an absolute equality among believers.

During our Saviour's ministry, it will be allowed that all power resided in him; and it is important to observe, that even then, before believers were constituted a church, parity was abolished by the ordinance of Jesus himself, in the appointment of the twelve apostles and the seventy disciples. And when the divine Founder of Christianity was making preparations for the maintenance of his religion after his departure hence, he did not abolish the distinction which he had previously instituted, but granted to the twelve apostles a still wider commission, a still more decided supremacy over the ordinary members of the church. " As my Father hath sent me," said he, " even so send I you. And when he had said this, he breathed on them, and said unto them, receive ye the Holy Ghost: whose soever sins ye remit, they are remitted unto them, and whose soever sins ye retain, they are retained." (John, xx. 21, 22, 23.) " All power is given unto me in heaven and in earth. Go ye, therefore, and teach all nations, baptizing them in the name of the Father, and of the Son, and of the Holy Ghost, teaching them to observe all things whatsoever I command you: and lo, I am with you alway, even unto the end of the world." (Matt. xxviii. 18, 19, 20.) Now the Episcopalian maintains that men who had received this commission could not be on a footing of equality as to ecclesiastical privileges with the great body of believers, who had no commission whatsoever.

If, however, all this be granted, and still the *permanence* of the commission be denied, the Episcopalian refers to our Lord's concluding words, " I am with you alway, even unto the end of the world;" and asks how Christ could be with the commission to the end of the world, if the commission itself was to last only for one generation. But, further than this, he refers to the acts of the apostles, as furnishing abundant evidence that they understood it to be the will of Christ that there should be a perpetual succession of privileged officers in the church. For, in the first place, the vacancy occasioned by the death of Judas was immediately filled by the appointment of Matthias; then a new order of Christian ministers was introduced under the name of deacons; afterwards Barnabas and Saul were ordained to be apostles; and finally, as the number of Christian congregations increased, a race of ministers superior to the deacons was instituted, to administer the sacraments, and to preside in the religious assemblies. To imagine that these were elected by the laity, and derived their authority from that election, could scarcely be credited, even if we possessed no evidence to the contrary. But St Paul (Eph. iv. 11) asserts, that when Christ ascended up on high, " *He* gave some apostles, and some prophets, and some evangelists, and some pastors and teachers;" that is to say, *he* commissioned the apostles, and empowered *them* to commission the inferior officers.

With respect to the age immediately succeeding the apostolic, we cannot of course refer to Scripture, but must have recourse to the records of primitive antiquity. And in referring to the *Fathers* for the historical fact, the Episcopalian claims for them nothing more than sufficient honesty to tell the truth when there existed no temptation to commit falsehood, or sufficient sense to abstain from a falsehood which it was impossible should be credited by any of their contemporaries. Now, of the earliest Christian writers, of those called apostolic fathers, because they are believed, on good grounds, to have been contemporaries and companions of the apostles, three, namely, Clement of Rome, Ignatius, and Hermas, explicitly state the existence of different orders of officers in the church, to whom great honour and obedience was due from the laity; whilst the remaining two, Polycarp and Barnabas, do not

touch upon ecclesiastical polity. Further than this it is unnecessary to descend, as every one now admits that in the age succeeding this, diocesan episcopacy prevailed over the Christian world, and continued undisputed till the Reformation.

Against this historical argument it may be urged, that the commission to the apostles was "to go and teach all nations, baptizing them in the name of the Father, the Son, and the Holy Ghost;" and that consequently a system which confines the right of preaching and baptizing to their successors in a particular *order* appears inconsistent with the wisdom and the goodness of God; as by such an economy an intolerable dominion would be established over the souls of men, and the very purpose for which the Saviour died might be defeated by the caprice of an ignorant or designing priesthood. To this objection the Episcopalian replies, that under the Mosaic law sacrifice was necessary for the expiation of sin, but that in many most important cases this expiation could be effected only by the instrumentality of a priest; that, in short, the objection, if it have any weight, weighs with equal force against the wisdom and justice of Providence in the ordinary government of the world. In every thing, he observes, that is valuable, whether of a temporal or a spiritual nature, mankind are subjected to mutual dependence; baptism must be conferred, and knowledge must be communicated, by some human being; and it is just as easy to imagine the whole *human race*, as the whole *clerical order*, unfaithful to their obligations.

The Episcopalian having by arguments of this nature attempted to prove that Christ did institute a *permanent order of ministers* in his church, proceeds, in the next place, by an inquiry of the same nature, to prove that this order was not *single*, but *threefold*. In the former inquiry he was united with the *Presbyterian* against the *Independent;* he has now to answer the arguments of the Presbyterian, who maintains that originally the Christian church contained no office higher than that of *presbyter* or *elder;* and, in opposition to him, the Episcopalian maintains that Christ and his apostles instituted divers orders in the church, of which that of *bishops* with authority over *presbyters*, and with the *exclusive right of ordination*, was the highest.

In behalf of the Presbyterian plea it is urged, that the titles of *bishop* and *presbyter*, being in the New Testament indifferently given to the same persons, cannot be the titles of distinct ecclesiastical officers; which appears still more evident from the ordination of Timothy, who, although he was the first *bishop* of Ephesus, received his episcopal character by the imposition of the hands of the *presbytery*. That one and the same man is, in the New Testament, styled sometimes a *bishop* and sometimes a *presbyter*, cannot be denied; but although every apostolic bishop was therefore undoubtedly a presbyter, it does not of course follow, says the Episcopalian, that every presbyter was likewise a *bishop*. In the *Old* Testament, Aaron and his sons are without any discrimination of order frequently styled *priests;* and in the *New*, both St Peter and St John call themselves *presbyters*, as St Paul, upon one occasion, styles himself a *deacon*, διακονος (Eph. iii. 7): yet no man ever supposed those apostles to have been such ecclesiastical officers as modern presbyters and deacons; and it is universally known, that in the Jewish priesthood there were different orders, and that Aaron was of an order superior to his sons. This being the case, the presbyters, by the laying on of whose hands Timothy was made a bishop, *may have been* of the same order with St Peter and St John; and if so, it follows that his ordination was *Episcopal.* At all events, we are certain, continues the advocate for Episcopacy, that it was not in the modern sense of the word *Presbyterian;* for the gift, which in the first epistle is said to have been "given by prophecy *with* the laying on of the hands of the presbytery," is in the second said to have been "in him *by* the putting on of the hands of St Paul." And here it is worthy of observation, that the preposition used in the former case is μετα, which signifies *concurrence* rather than instrumentality; but *that* in the latter is δια, which, as every Greek scholar knows, is prefixed to the *instrumental cause* by which any thing is effected; so that whatever may have been the order of the presbyters who *concurred*, St Paul appears to have been the *sole* ordainer. But by the confession of all parties, St Paul was a bishop in the highest sense in which that word is ever used; and the powers of the episcopate not being parcelled out among various partners, of whom each possessed only a share, the imposition of his hands was sufficient for every purpose which could have been effected by the hands of the whole college of apostles.

It appears, therefore, that from the promiscuous use of the titles *bishop* and *presbyter*, and from the *ordination of Timothy*, nothing can with any certainty be concluded on either side of this celebrated question. But if, instead of resting on mere *words*, which, when taken alone and without regard to the context, are almost all of ambiguous signification, we attend to some important *facts* recorded in the New Testament, the Episcopalian thinks we shall discover in these sufficient evidence that the government of the primitive church was Episcopal.

During our Saviour's stay upon earth, it is undeniable that he had under him two distinct orders of ministers, the twelve and the seventy; and after his ascension, immediately before which he had enlarged the powers of the *eleven*, we read of *apostles*, *presbyters*, and *deacons*, in the church. That the presbyters were superior to the deacons, and the apostles superior to both, is acknowledged by the supporters of presbyterian parity; but it has been said, that in Scripture we find no intimation that the apostolic order was designed for continuance. A Quaker says the same thing of water-baptism; and the Episcopalian observes, that it would be difficult to point out by what passage of Scripture, or what mode of reasoning, those who upon this plea reject the apostolic order of Christian ministers, could overthrow the principles upon which the disciples of George Fox reject the use of that rite which our Saviour instituted for the initiation of mankind into his church. They were the *eleven* alone to whom Christ said, "go ye therefore and teach all nations, baptizing them in the name of the Father, and of the Son, and of the Holy Ghost;" and hence, although we frequently find presbyters and deacons administering the sacrament of baptism, we must conclude, that as a *judge* administers justice by authority derived from his *sovereign*, so those *inferior officers* of the church administered baptism by authority derived from the *apostles*. Indeed, had they pretended to act by any other authority, it is not easily to be conceived how *their* baptism could have been the baptism instituted by Christ; for it was not with the *external washing*, by whomsoever performed, but with the *eleven* and their successors, that he promised to be "always, even unto the end of the world."

We have already noticed that the *eleven*, acting, as all orthodox Christians allow, by the extraordinary direction of the Spirit, never appear to have supposed that the commission with which they were invested was to terminate with them. On the contrary, they admitted Matthias, Barnabas, and Paul, to the name and authority of apostles, and Timothy and Titus to some office which, it is evident, was superior to that of either ancient or modern presbyters. Supposing it then granted that Timothy was commissioned by the apostle Paul not to found a church where the gospel had been hitherto unpreached, but to

execute some office in one previously founded, the Episcopalian maintains that the directions given by the apostle could be addressed to none but a bishop, that is, to one possessing an ecclesiastical authority superior to that of presbyters. For in Timothy (iv. 2–6) we read, "I besought thee to abide still at Ephesus, when I went into Macedonia, that thou mightest charge some that they teach no other doctrine, neither give heed to fables and endless genealogies. Let the presbyters that rule well be counted worthy of double honour; especially they who labour in the word and doctrine. Against a presbyter receive not an accusation but before two or three witnesses. Them that sin rebuke before all, that others also may fear. Lay hands suddenly on no man, neither be partaker of other men's sins." Now, an individual right to direct *presbyters* as to the doctrine they preached, to receive accusations against them, to rebuke the offending, to confer authoritative approbation upon the deserving, and finally, to *ordain*, are exactly the offices which belong to a bishop. The right to perform these, if derived from an appointment by presbyters, would have constituted a *superintending presbyter;* but the right being conferred by apostolic authority, raised their professor to higher *order*, and this higher order is the Episcopal.

It is unnecessary to pursue the argument in the case of Titus, bishop of Crete, whose episcopacy is equally clear with that of Timothy; and if no other diocesan bishops are mentioned in the Acts or Epistles, we need not wonder when we reflect how little is said of the greater part of the apostolic body.

We perceive, then, that as far down as the history of the church is warranted in Scripture, there always existed *imparity* among the ministers of religion, and that the apostles ordained certain officers to superintend or be *bishops* over the presbyters. And when from the inspired penmen of the New Testament he proceeds to examine the succeeding writers of the Christian church, the Episcopalian finds such multiplied and concurring evidence of the apostolic institution of episcopacy, as he thinks it impossible to resist without denying the truth of all ancient history, and even shaking the pillars of revelation itself; for, "in the noble army of martyrs," the witnesses of the episcopal government of the church are earlier, and by far more numerous, than those who testify that the gospel of St Matthew was written by that apostle, or that the book of the Apocalypse is canonical Scripture. The authority of the Fathers indeed is at present very low; but should they be allowed to be as fanciful divines and as bad critics as their worst enemies are pleased to represent them, this would detract nothing from their evidence when they bear witness to the constitution of the church in their own times; for of their honesty there can be no doubt; and what the Episcopalian wants of them is only their testimony to matters of fact which fell under the cognizance of their own senses, and about which therefore they could not be deceived. It is here indeed chiefly that he triumphs over his antagonists. In the second and third centuries there was no general council, nor any Christian sovereign. A prelacy therefore, he urges, could not have been *universally* introduced, during that period, either by a concert among the clergy, or by the authority of the civil magistrate.

That at the close of the first or apostolic century the whole Christian world was *Presbyterian*, and that, as we know to have been the case, at the close of the second it was entirely *Episcopal;* that of the cause or progress of the change not a word should be mentioned by the contemporary writers; that whilst Episcopacy was a foul usurpation of the rights of Christ's flock, every Christian writer from Clement downwards should speak of it as a most excellent and even divine institution; that no single presbyter throughout the world should, as far as we know, have said a single word in defence of his insulted order; all this, the Episcopalian maintains, is so utterly improbable as to justify his regarding it as a fable, and one not very cunningly devised.

The candid Episcopalian, however, allows, that in the apostolic age there may have been some churches which at first had only bishops and deacons to perform the offices of religion; for when the number of disciples in any place was so small that they could all meet in one assembly, there was no necessity for any other order of ministers; but it appears that, from the very beginning, *bishops, presbyters*, and *deacons* were settled in all the *larger* cities of the Roman empire; and it was in those days an allowed maxim, that without a *bishop* there could be *no church.* The better to understand the original state and institution of episcopacy, it is necessary to observe, that the empire, which contained almost all the known part of the Christian world, was divided originally into provinces of two kinds, the one called *consular*, the other *prætorian*, of which the former were either larger, or of more political importance. In the reign of Augustus the consular provinces were placed under the direct control of the emperor, and were administered by *legates* generally of consular rank; whilst the prætorian were left under the control of the senate and people, and were governed by a *proconsul*, as Asia was. (See Acts, xix. 38.) There was still a third class of smaller provinces retained by the emperor, and governed in general by men of equestrian or even inferior rank, under the title of *procurators;* of these Judæa was one. A province comprehended the cities of a whole region; and in the age of the apostles each city was under the immediate government of certain magistrates within its own body, known by the name of βουλη, or *senatus, ordo*, and *curia*, the states and court of the city. Those magistrates were subordinate to the *prætor* or *proconsul;* but among them there was *one* superior to the rest, called sometimes *dictator* and sometimes *defensor civitatis*, whose jurisdiction extended not only over the city itself, but likewise over all the adjacent territory. That territory was denominated προαστεια, or the suburbs, and often reached to the distance of ten or twelve miles round the city, and sometimes much farther, containing within it many villages and small towns under the government of the city magistrates. From some passages in the New Testament, and from the concurring evidence of the earliest writers of the church, it appears to have been the purpose of the apostles to settle a bishop in every city where there was a civil magistracy; but as they could not be personally present in all places at once, it was natural for them to enter upon the great work of converting the nations by first preaching the gospel in that city of each province which was the ordinary residence of the governor; because to it there must have been the greatest resort of people, who would carry the glad tidings with them into the country when they returned. Accordingly, having dispersed themselves over the empire, and made numbers of proselytes in the principal cities, they fixed in each, where they saw it necessary, a *bishop*, with a college of *presbyters* and *deacons*, and gave to those bishops, who were at first called *apostles*, a commission, as the *other* cities of the province should be converted, to fix bishops in them also.

In some of the smaller cities, it is extremely probable that a bishop and a deacon were for a short time the only ecclesiastical officers, till the number of Christians increased so much as to make it impossible for them all to assemble in one house for the purposes of public worship. The bishop then ordained *presbyters* to officiate in those congregations where he himself could not be present, and

to assist him in other parts of his pastoral office; but in all their ministrations the presbyters were subordinate to him, who was the chief pastor within the city, who composed the prayers which were offered up in public, and to whom all the other ministers of religion were accountable for their conduct. As long as the number of the faithful was confined within the *walls* of the city, it appears that the bishop with his presbyters and deacons lived together as in a college; that divine service was every Lord's day, or oftener, performed in what was afterwards called the cathedral or mother-church, by the bishop himself, assisted by some of his clergy; and that the congregations which met in other churches, having no *fixed* pastors, were supplied by such presbyters as the bishop chose to send to them from his own church. Whilst matters continued in this state, the clergy had no other revenues than what arose from the voluntary oblations of the people; which were indeed so large as not only to support them with decency, but likewise to answer other ends of charity and munificence. They were commonly divided into four equal parts; of which one was allotted to the bishop, a second to the inferior clergy, a third to the poor, and a fourth to keep the churches in repair; and it was considered as a part of the bishop's duty to take care that the offerings should be faithfully applied to these purposes.

When converts increased in number, and churches were built in the suburbs, each of these churches had a fixed pastor similar to a parish-priest amongst us; but still those pastors, as well as the city clergy, ministered in subordination to the bishop, whose authority extended as far as the civil authority of the Roman magistrate, within which district or diocese it was supreme over all orders of Christians. This every man knows who is acquainted with ecclesiastical history; for the bishop alone could ordain *priests* and *deacons*, administer the rite of *confirmation*, *absolve penitents* who were under church censure, and *exclude from communion* heretics and notorious offenders; and from his sentence there lay no appeal but to a synod of comprovincial bishops.

Such synods were in each province convened by the bishop of the chief city: for the apostles having been careful to place in those cities men of the most eminent gifts and abilities, the other bishops of the provinces applied to them for advice upon every emergency, and paid a particular deference to them upon every occasion. So that though all bishops were of equal authority *as bishops*, yet when they met to consecrate a new bishop, or to deliberate upon the affairs of the church, they yielded a precedency to the bishop of the metropolis, who called them together, and who sat as *president* or *moderator* of the synod. Hence the origin of metropolitans or *archbishops*, whose authority was so considerable, that though there is not a doubt but the *election* of bishops was anciently placed in the clergy and people of the vacant diocese, yet the bishop *elect* could not be *consecrated* without the consent of the archbishop of the province.

In consequence of the very extensive powers with which the primitive bishops were vested, they are commonly styled in the writings of those times *presidents*, *provosts*, or *inspectors* of the church, *chief priests*, *princes of the clergy*, and even *princes of the people*; but their authority was wholly spiritual. Those prelates, imitating the example of their Divine Master when on earth, neither possessed nor assumed to themselves any jurisdiction over the *properties* or *civil rights* of men. In consequence of St Paul's having reprimanded the Corinthians for going to law before the *unbelievers*, they were indeed often chosen as *arbiters* of such civil disputes as arose between individuals under their episcopal government; but on these occasions they could not act unless the submission was *voluntarily* made by *both* the contending parties, and *then* their decision was final. When the empire became Christian, this privilege was confirmed to them by law; for any *civil* cause depending before a court of justice could be withdrawn, and by the mutual consent of parties be submitted to the arbitration of the bishop, whose award, which in former times could be enforced only by the terror of church censures, was then enforced by the secular magistrate. In *criminal* causes, where the trial might be for life or death, they were prohibited, both by the canons of the church and by the laws of the state, from acting as judges; and therefore they never suffered such causes to come before them, excepting when it was necessary that the person accused, if found guilty, should be excluded the communion of the faithful.

Be this as it may, it is certain that, through the liberality of the Christian emperors, the bishops enjoyed large revenues and many valuable privileges; but it does not appear that they had any rank or authority, as *barons* or *temporal princes*, till the Gothic nations, which subverted the Roman empire, had embraced the Christian faith. As Christianity incapacitated the leaders of those tribes from officiating as chief priests at the religious rites which were usually celebrated at the opening of their public assemblies, the bishops came naturally to discharge that duty on such occasions, when they must have shared in the rank by sharing in the functions of the chief. The situation in which they thus appeared at the opening of all political conventions, enabled them to join with much effect in the deliberations which ensued; and their superior knowledge, their sacred character, and their influence with the people, soon acquired them power equal to their rank. They must therefore have been thought entitled to obtain admission into that council which was formed by the king and the lay-chiefs at the national assemblies; and as they balanced the authority of those chiefs, we cannot doubt of the king's disposition to give the utmost effect to their claim. Accordingly, we find the dignified clergy, who received large grants of land to be held on the same tenures with the lands of the lay magistrates, presiding along with those magistrates in the provincial assemblies of every degree in all the Gothic nations, and enjoying every advantage of rank and authority in their national diets. Hence the bishop of Rome, and several bishops in Germany, have, like the dukes and marquises of that empire, been for a long time sovereign princes; and hence too the bishops of England and Ireland have always sat, and have an equal right with the lay-peers to sit, in the upper house of parliament. It is however obvious, that, as far as episcopacy is of *apostolical* institution, those peers and princes possess not the *original* character in any higher degree than the bishops in America, who are merely on a footing of equality with other citizens, or those of Scotland, who are little more than the ministers of a small body of dissenters from an established church.

Having thus traced what we may call the progress of episcopacy from the simple purity of apostolic times up to the gorgeous prelacy of the middle ages, it seems proper, before concluding, that we should briefly allude to the history and present state of episcopacy in Scotland.

About the time of the Reformation, the want of order and decency in the worship of the reformed church was abolished in the reign of James VI. by the establishment of episcopacy on very liberal principles. This mode of worship obtained the sanction of the most respectable part of the nation, and continued to flourish under the auspices of government, till it was overthrown by the adherents to the *national covenant*. Its restoration was, however, ef-

fected in the year 1662, and twenty-seven years subsequently it was again abolished by the supporters of the Prince of Orange, afterwards William III.

It may be proper to observe, that the Scotch Episcopal Church had no public liturgy during her legal establishment. It is indeed true that the English book of common prayer was used by the first reformers, and there is reason to believe that John Knox himself was by no means inimical to fixed forms of prayer, nor to clerical subordination; but his successor, Andrew Melvil, introduced an equality among the clergy, and excited the minds of the people against the liturgy to such a degree, that an attempt to modify the prayer-book for the use of the Church of Scotland was productive of the solemn league and covenant, and the subsequent ruin of Charles I.

During the reign of William III. the episcopalians were treated with some degree of severity, because they could not transfer to him that allegiance which they had sworn to King James. It is said that they were prohibited from officiating on the Sabbath-day, except "in their own hired houses, where they received such friends as chose to come in unto them." In this manner was their worship conducted, praying either extempore, or from premeditation, till the accession of Queen Anne, when the English liturgy was introduced by degrees into Scotland, under the sanction of an act of parliament, passed on the 3d of March 1712, "to prevent the disturbing of those of the episcopal communion in that part of Great Britain called Scotland, in the exercise of their religious worship, and in the use of the liturgy of the Church of England." But as their attachment to the house of Stuart was well known, they were, at the rebellion in 1715, laid under some restraints, yet neither severe in their nature, nor of any long continuance, since in 1730 their places of worship were as numerous as before, and frequented by numbers both of rank and respectability, many of whom held places under government.

In England Dr Sancroft, archbishop of Canterbury, with five other bishops, were deprived of their sees for refusing their allegiance to King William; a circumstance which occasioned a schism in the church, as they were extremely popular. Different opinions were entertained respecting the nature and design of the Lord's Supper, and the controversy infected the episcopalians of Scotland. On the death of Dr Rose, the proscribed bishop of Edinburgh, the diocesan form of church government was opposed by such of the presbyters as had been raised to the episcopal dignity, and it was proposed to govern the whole church by a college of bishops. This plan, for the adoption of which no precedent could be found in the annals of history, was successfully opposed by many of the most enlightened bishops, and it was of consequence abandoned.

After the rebellion of 1745 additional acts of considerable severity were passed against the Scottish Episcopalians, the worst effect of which was the formation of many congregations using the English liturgy, and styling themselves Episcopalians, whilst they and their ministers were living in separation from the bishops of the country. All restraints upon Scottish Episcopalians were, however, removed by the act of 1792; since which period they have enjoyed full liberty of conscience, in common with other Dissenters.

The repeal of the penal acts of course tended to unite the independent chapels above mentioned to the episcopal church; but an impediment still existed, which delayed the progress of this union for several years. The Scottish Episcopal Church had never yet adopted the English Confession of Faith; and though the act of 1792 required that every tolerated episcopalian minister should sign the *Thirty-nine Articles*, still, as might have been expected, those ministers were not prepared immediately to sign a declaration of faith at a secular mandate. There consequently remained an ostensible reason for separation till the year 1804, when a convocation of the episcopal church declared their readiness to sign the Thirty-nine Articles of the Church of England, in the manner enacted by the act of 1792.

The cause of separation being thus removed, the English chapels began immediately to unite themselves to the Scottish Episcopal Church, and to submit to the authority of the bishop within whose jurisdiction they lay; but at the present time (1855) there are ten congregations in Scotland who use the English liturgy that refuse obedience to the Scottish bishops. The Episcopal Church in Scotland is now governed by seven bishops, having under them about 150 presbyters intrusted with the cure of souls.

EPISCOPIUS (or Bisschop) Simon, the most learned of the Arminian divines of the seventeenth century, was born at Amsterdam in 1583. He studied philosophy and theology at the university of Leyden; and in the contests between the Gomarists and the followers of Arminius, which at that time first began to divide the church, he espoused the party of the latter. In 1610, the year in which the Arminians presented their famous Remonstrance to the states of Holland, he was ordained minister of a small village in the neighbourhood of Rotterdam; and in the following year he advocated the cause of the Remonstrants at the Hague Conference. In 1612 he succeeded Gomar as professor of theology at Leyden; and in spite of the abuse and violence of the Gomarists, continued to hold his chair till 1619, when he was deposed and expelled by the synod of Dort. Having retired to France, Episcopius devoted the greater part of his energies to the promotion of the Arminian cause; but the attempt of Wadding to win him over to the Romish faith involved him at the same time in a controversy with that famous Jesuit. After the death of the stadtholder Maurice, the violence of the Arminian persecution began to abate; and Episcopius was permitted, in 1626, to resume his duties in the Remonstrant church of Rotterdam. He was afterwards appointed rector of the Remonstrant college at Amsterdam, where he died in 1643, at the age of 60. His works were collected in 2 vols. fol., by his successor Curcellæus, who, as well as Limborch, has furnished a biography of this celebrated divine.

EPISODE, a separate incident, story, or action, introduced in a poem or other work of fiction; an incidental digression, separate from the main subject, but naturally arising from it. See Poetry.

EPISTLES and Gospels, in the liturgy of the Church of England, portions of Scripture selected from the writings of the evangelists and apostles, and appointed to be read, in the communion service, on Sundays and holidays. They are believed to have been selected and put into the lectionary by St Jerome.

EPITAPH (ἐπι *upon*, and τάφος *a sepulchre*), an inscription on a tomb. It is also used for an eulogium, in prose or verse, composed in honour of a person deceased, without any intent to be engraven on a monument.

It has been doubted whether the ancient Jews inscribed epitaphs on tombs; yet it is certain that instances of epitaphs of very ancient date have been found among them. The Athenians commonly inscribed only the name of the dead, with the epithet χρηστός, *good*, or ἥρως, *hero*, and the word χαίρε, intimating their good wishes; but the name of the deceased's father and that of his tribe were occasionally added. The Lacedæmonians allowed epitaphs to none but those who had died in battle. The Romans inscribed their epitaphs *diis manibus;* and frequently introduced the dead, by way of prosopopœia, speaking to the living.

The English language is perhaps richer than any other in compositions of this kind. That discovered by Sir Walter Scott, on a defaced tomb-stone in the churchyard of Melrose, is among the finest in its own vein—

> Earth walketh on the earth glistering in gold;
> Earth goeth on the earth whither it wold;

Earth builds on earth palaces and towers,
Earth says to earth, all shall be ours.

Ben Jonson's epitaph on the Countess of Pembroke is well known:—

Underneath this marble hearse
Lies the subject of all verse,
Sydney's sister, Pembroke's mother;
Death, ere thou hast slain another
Wise and good and fair as she,
Time will throw his dart at thee.

Equally happy in its own way is that by an unknown author, inscribed on a tomb in a cemetery in the Isle of Wight:—

Forgive, blest shade, the tributary tear,
That mourns thy exit from a world like this;
Forgive the wish that would have kept thee here,
And stayed thy progress to the realms of bliss.

No more confined to grovelling scenes of night,
No more a tenant pent in mortal clay;
Now should we rather view thy glorious flight,
And mark thy progress to the realms of day.

In a far different vein is that composed by Benjamin Franklin on himself:—"The body of Benjamin Franklin, printer (like the cover of an old book, its contents torn out and stripped of its lettering and gilding), lies here, food for worms; yet the work itself shall not be lost, for it will (as he believed) appear once more in a new and more beautiful edition, corrected and amended by the Author."

For simplicity and appropriateness, that on Copernicus in a church at Cracow is remarkable:—

Sta, sol, ne moveare.

In this case the words of Scripture, which were used as a pretext for the persecution of the great truth which he discovered, are here employed to form the astronomer's epitaph.

Similar in spirit to this is Pope's famous epitaph on Newton:—

Nature and Nature's laws lay hid in night,
God said, Let Newton be, and all was light.

Many others of Pope's epitaphs are remarkable. We select that on Mrs Corbet:—

Here rests a woman, good without pretence,
Blest with plain reason and with sober sense;
No conquests she—but o'er herself—desired,
No arts essayed but—not to be admired.
Passion and pride were to her soul unknown,
Convinced that virtue only is our own.
So unaffected, so composed a mind;
So firm, yet soft; so strong, yet so refined;
Heaven, as its purest gold, by tortures tried:
The saint sustained it, but the woman died.

Of satirical epitaphs the French language affords some very piquant examples. One of the best known is that of Piron on himself, written in a spirit of revenge against the French Academy:—

Ci-gît Piron, qui ne fut jamais rien,
Pas même Académicien.

The next is scarcely less happy. It may still be seen in Père-la-Chaise at Paris:—

Ci-gît ma femme. Ah! qu'elle est bien
Pour son repos et pour le mien.

In this vein one of the most famous epitaphs is that of Dr Arbuthnot on the infamous Col. Chartres:—"Here continueth to rot the body of Francis Chartres, who, with an inflexible constancy and inimitable uniformity of life, persisted, in spite of age and infirmities, in the practice of every human vice excepting prodigality and hypocrisy; his insatiable avarice exempted him from the first, his matchless impudence from the second. Nor was he more singular in the undeviating pravity of his manners than successful in accumulating wealth. For without trade or profession, without trust of public money, and without bribe-worthy service, he acquired, or more properly created, a ministerial estate. He was the only person of his time who could cheat without the mask of honesty, retain his primeval meanness when possessed of ten thousand a-year; and having daily deserved the gibbet for what he did, was at last condemned to it for what he could not do. Oh! indignant reader, think not his life useless to mankind. Providence connived at his execrable designs, to give to after-ages a conspicuous proof and example of how small estimation is exorbitant wealth in the sight of God, by his bestowing it on the most unworthy of all mortals."

EPITHALAMIUM (ἐπι, and θάλαμος *a bed-chamber*), in *Antiquity*, a nuptial song or poem in praise of the bride and bridegroom, and praying for their prosperity.

Among the Jews epithalamia were sung at the door of the bride, by her female companions, the evening before the marriage. The Greek epithalamium was performed by a chorus of boys and girls when the bride and bridegroom entered the bridal chamber; and the wedded pair were saluted the next morning with the same song slightly altered. The practice amongst the Romans was similar; the chorus, however, consisting of girls only, who sang at the door of the nuptial-chamber till midnight; but their epithalamia were frequently obscene.

EPOCH, or EPOCHA (from ἐπέχειν *to check*), in *Chronology*, a fixed point of time from which succeeding years are numbered.

EPODE, in *Lyric Poetry*, the third and concluding part of the ode; that which follows the strophe and antistrophe; the ancient ode being divided into strophe, antistrophe, and epode. The word is now used as the name of any little verses that succeed one or more great ones. Thus a pentameter after an hexameter is an epode. The term as applied to a book of Horace's poems, signifies merely additional or supplementary.

EPPING, a market-town of the county of Essex, in the hundred of Waltham, 17 miles N.N.E. from London. It is situated in a district formerly very woody, and preserved by our ancient monarchs for the enjoyment of field sports. It was then called Waltham Forest, and extended almost to the capital. In the same neighbourhood also was Hainault Forest, where a fair was held for many centuries under a remarkable tree, well known by the name of Fairlop Oak, which existed till recently, and was of prodigious size. This town is singularly irregular in its appearance; one part of it, called Epping Upland, where the church stands, being nearly a mile and a half distant from the other part, named Epping Street, which is the largest portion, and where the market is held. It has long been famed for its sausages and pork, and especially for its butter. Pop. of parish (1851) 2255.

EPROUVETTE, the name given to various machines for ascertaining the comparative strength of different kinds of gunpowder. One of the simplest and best of these consists of a small gun fixed in a frame, which is suspended as a pendulum from a horizontal bar. When the gun is fired, the recoil causes the frame to oscillate, and the extremity of the arc of vibration (which is marked by a sliding index) denotes the comparative force of the explosion.

EPSOM, a market-town in the county of Surrey, 14 miles S.W. of London. Pop. (1851) 3390. The principal building is the parish church, a Gothic edifice rebuilt in 1825. The once celebrated mineral springs discovered in 1618, and from which Epsom salts were first extracted, are now neglected. The Epsom races are held in the vicinity, and attract an immense concourse of people. The grand stand, erected in 1829–30, can contain 7500 persons.

EPULONES, in *Roman Antiquity*, certain priests, originally three in number, who were first created A.U. 558, by the pontifices, to superintend the *epulæ* or feasts in the sacred games and festivals. Their number was at length augmented from three to seven, and by Julius Cæsar was increased to ten; but after his time their number was again reduced to seven. Like the pontifices and the augures, the epulones formed a collegium at Rome.

EQUATIONS.

1. In all the applications of algebra, it is not the magnitudes concerned that we immediately consider, but merely their proportions. In every class of quantities of the same kind, one being adopted as the unit of comparison, all the rest are referred to this standard, and are represented by the proportions they bear to it. The letters of the alphabet, or other symbols, used in algebra, are not, therefore, properly speaking, the representatives of magnitudes; they denote ratios, or abstract numbers, viewed, as in the fifth book of Euclid, in the most general manner, and independently of any particular system of arithmetic or numeration.

The ancient geometry follows a different procedure. In that science the attention is in every case confined to the magnitudes under actual consideration. A general property of triangles is established, by showing that it is true of any particular triangle that comes under the proposed hypothesis. The geometer contemplates particular instances, presenting for the most part relations not very complex, and easily kept in view. On this account he carries on his investigations with the greatest clearness, and is in no danger of falling into contradiction or paradox. But his science is little susceptible of general methods. If any process within the compass of the ancient geometry be entitled to that appellation, it is what is called the method of exhaustion. Every geometer perceives that all the demonstrations under this head have the closest analogy. Yet, after a hundred applications, it is still necessary, in any new case, to pursue the reasoning through all its details, without deriving assistance from any general conclusion previously obtained.

Algebra possesses a great advantage over geometry in generalizing its processes. Problems relating to magnitudes of the most different kinds, nevertheless, lead to similar expressions in numbers. Questions in geometry, in mechanics, or concerning mercantile business, are made to depend on the same rules for their solution. It may be said that algebra and the modern analysis accomplish, for all the mathematical sciences, the project, entertained by some ingenious men, of an universal and philosophical language, which, being founded on an exact scrutiny into the nature of things, and on what they possess in common, might greatly facilitate the acquisition and the extension of our knowledge.

The spirit of generalization peculiar to algebra is nowhere more conspicuous than in the doctrine of equations. Every determinate problem that can occupy the attention of the mathematician, is ultimately reduced to the finding of such numbers as are necessary to determine the unknown quantity or quantities, by means of the equations that subsist between those numbers, and others which are given in the question. A wide field of mathematical investigation is thus brought under a limited number of algebraic expressions.

In treating of equations, it will not be necessary to begin with laying down a formal definition. We confine ourselves, in this article, to the consideration of such equations as contain only one unknown quantity. We further suppose that the elementary operations preparatory to solution are already performed; so that the unknown quantity is clear of radical signs, and is nowhere found in the denominator of a fraction; likewise that all the separate terms are brought to one side of the sign of equality, and arranged in such a manner that the first term, which must always be positive, and have unit for its index, contains the highest power of the unknown quantity, or x; the second term contains the next highest power, and so on, the term which does not contain x being placed last. This arrangement must always be understood when any term is distinguished by the order it stands in; but it will sometimes be convenient to write the terms in an inverted order, arranging them according to the indices of the unknown quantity.

Equations.

Equations are divided into different classes or orders, according to the highest power of the unknown quantity found in their terms.

An equation of the first degree, or a simple equation, is one which contains x only, without any of its powers, as $x - \mathrm{A} = 0$.

A quadratic equation, or one of the second degree, contains the square of x, as $x^2 - \mathrm{A} = 0$, or $x^2 - \mathrm{A}x + \mathrm{B} = 0$.

A cubic equation, or one of the third degree, contains the cube, or third power of x, as $x^3 - \mathrm{A} = 0$, or $x^3 - \mathrm{A}x^2 + \mathrm{B}x - \mathrm{C} = 0$.

A biquadratic equation, or one of the fourth degree, contains the fourth power, or biquadrate of x, as $x^4 - \mathrm{A} = 0$, or $x^4 - \mathrm{A}x^3 + \mathrm{B}x^2 - \mathrm{C}x + \mathrm{D} = 0$.

And, in general, an equation of the n^{th} degree contains the n^{th} power of x, and the powers inferior to the n^{th}, such as

$$x^n - \mathrm{A}x^{n-1} + \mathrm{B}x^{n-2} \ldots\ldots\ldots\ldots\ldots - \mathrm{M}x + \mathrm{N} = 0.$$

A root of an equation is a value of the unknown number x. Thus, if a represent a number, and if its powers, a, a^2, a^3, when they are substituted in the equation for x, x^2, x^3, &c. produce an equality between the positive and negative terms, then a is a root of the equation, and it is a positive root; but if, for x, x^2, x^3, &c. we must substitute $-a$, a^2, $-a^3$, &c. which are the powers of $-a$, in order to obtain the like equality, then a is a negative root of the equation.

What we have here called roots are more generally named *real roots*, to distinguish them from those expressions to which the appellation of *imaginary or impossible roots* has been given. As it will conduce to perspicuity, we shall always use the word root in the sense here defined, unless when imaginary or impossible roots are expressly mentioned.

From the definitions laid down, it follows that the negative roots of the equation,

$$0 = \mathrm{N} + \mathrm{M}x + \mathrm{L}x^2 + \mathrm{K}x^3 +, \&c.$$

are the same with the positive roots of the equation,

$$0 = \mathrm{N} - \mathrm{M}x + \mathrm{L}x^2 - \mathrm{K}x^3 +, \&c.$$

in which the signs only of all the terms containing the odd powers of x are changed. For the same result is obtained, whether we make x equal to $-a$ in the first equation, or to $+a$ in the second.

2. A great advantage has resulted from the practice introduced by Harriot, of writing all the terms of an equation on one side of the sign of equality. The polynomes formed by all the terms thus brought together are rational and integral functions of the unknown quantity; and the question is, to find in what circumstances such expressions are equal to zero. The most likely way of succeeding in this research, is to resolve the functions into their most simple component factors. Harriot supposed that every rational function can be produced by the continued multiplication of binomial factors, and in

this he has been followed by succeeding algebraists. The modern theory of equations is entirely founded on this supposition, which, although it has not been demonstrated, has yet, in some measure, been verified in the progress of the science, and by the admission of those artificial expressions called imaginary or impossible quantities. But there is a distinction between the real and impossible binomial factors of a rational polynome; for the first are expressions complete and significant by themselves, without reference to other quantities; whereas one impossible factor necessarily supposes the existence of another, the two related expressions being such that their multiplication produces one real factor of the second degree. Thus, every pair of impossible factors is equivalent to a real quadratic factor; and, by an unavoidable consequence of the forced supposition made by Harriot, the attention of algebraists has been drawn to the two impossible expressions, instead of the real one which they compose. In order to place the doctrine of equations and the theory of impossible roots on a solid foundation, it appears necessary to attempt the resolution of rational functions into their component factors by a rigorous analysis, free from arbitrary suppositions.

To resolve the rational function $f(x)$ into its component factors, we must begin with inquiring whether it can be divided without a remainder, by a division such as $x-a$, or $x+a$. If it can, the proposed function will be equal to $(x\mp a)\times f'(x)$, where $f'(x)$, the quotient of the division, is a function similar to $f(x)$, but of an order one degree lower. In like manner, it may be possible to reduce $f'(x)$ to a degree still lower, by means of one or more divisors of the same form; and, in certain cases, the first function may be entirely exhausted by successive binomial divisors. When this happens, the divisors $x-a$, $x-b$, $x-c$, &c. will be equal in number to the exponent of the highest power of x, and their continued product will be equal to $f(x)$. It is evident, that by multiplying together a proper number of such factors, an algebraic expression may be formed similar to any rational and integral function, and the co-efficients of this product will likewise contain as many quantities to be determined at pleasure as there are co-efficients in the given function. But we should reason badly if, from this process of composition, we should infer that a product arising from the multiplication of a certain number of simple factors may have any given co-efficients, or will coincide with any proposed polynome of the same degree. This is a point that can be ascertained only by a process of analysis or resolution, and by seeking all the binomial divisors any given function admits of. In fact, the cases are extremely rare in which an algebraic function can be completely exhausted by real binomial divisors. There are many polynomes which have not a single divisor of this kind; and, in the progress of resolution, we generally arrive at a function which cannot be further divided. When this is the case, it must be tried whether a quadratic divisor, as x^2+mx+n, will not be successful in lowering the function. But here it must be observed that such divisors are of two kinds; one, as $(x-\varrho)^2-r^2$, which can be resolved into two binomial factors; and one, as $(x-\varrho)^2+r^2$, which cannot be so resolved without introducing imaginary or impossible expressions. Now, to divide by a divisor of the first kind is the same thing as to divide by the two binomial factors of which it is composed; and, therefore, it is the second kind of quadratic factors only that need be tried, or that can succeed, in lowering a function already deprived of all its simple divisors. After quadratic divisors, those of the third degree would naturally come to be considered; but this is unnecessary, because algebraists have found that every rational function may be completely exhausted by simple and quadratic factors.

What has now been said naturally distributes the subject under two heads; one treating of the simple or binomial factors, and the other of the quadratic or trinomial factors, of algebraic equations.

Binomial Factors.

3. The first object of inquiry must be to find the conditions necessary, in order that a binomial quantity, as $x-a$, or $x+a$, shall divide a rational polynome without a remainder. Suppose that $x-a$ is a divisor of the polynome,

$$x^n+Ax^{n-1}+Bx^{n-2}\ldots\ldots\ldots+Mx+N,$$

which we shall denote by $f(x)$: then we shall have

$$f(x)=N+Mx+Lx^2+Kx^3+,\ \&c.$$
$$f(a)=N+Ma+La^2+Ka^3+,\ \&c.$$

wherefore, by subtracting and dividing by $x-a$, we get

$$\frac{f(x)}{x-a}-\frac{f(a)}{x-a}=M\frac{x-a}{x-a}+L\frac{x^2-a^2}{x-a}+K\frac{x^3-a^3}{x-a}+,\ \&c.$$

Now, it is known that the difference between any like powers of two numbers is exactly divisible by the difference of those numbers: hence all the quantities on the right-hand side of the sign of equality form an integral expression. But as $f(a)$ does not contain x, it cannot be divisible by $x-a$; it follows, therefore, that $f(x)$ cannot be divisible by $x-a$, unless $f(a)=0$; and it is obvious that this condition is the only one necessary. Thus, the polynome $f(x)$ will be divisible by $x-a$ when a is a positive root of the equation $f(x)=0$, otherwise not.

Again, let the divisor be $x+a$; then,

$$f(x)=N+Mx+Lx^2+Kx^3+,\ \&c.$$
$$f(-a)=N-Ma+La^2-Ka^3+,\ \&c.$$

and by proceeding as before,

$$\frac{f(x)}{x+a}-\frac{f(-a)}{x+a}=M\cdot\frac{x+a}{x+a}+L\frac{x^2-a^2}{x+a}+K\cdot\frac{x^3+a^3}{x+a}+,\&c.$$

Here again all the divisions on the right-hand side of the sign of equality can be exactly performed; and we must, therefore, conclude that $f(x)$ will be divisible by $x+a$ only when $f(-a)=0$, that is, when a is a negative root of the equation $f(x)=0$.

Now $x\mp a$ being a divisor of $f(x)$, the quotient, which we may denote by $f'(x)$, will be a polynome of $(n-1)$ dimensions, or one degree lower than $f(x)$; and we shall have

$$f(x)=(x\mp a)\times f'(x).$$

From this equation it appears that every value of x that makes $f'(x)$ equal to zero, will likewise make $f(x)$ equal to zero; consequently every binomial divisor of the first function will likewise be a divisor of the second. And if $f'(x)$ has no roots, and no binomial divisors, neither will $f(x)$ have any roots except $\pm a$, nor any binomial divisors except $x\mp a$. Suppose that the polynomes $f(x)$ and $f'(x)$ have the common root $\pm b$; they will likewise have the common divisor $x\mp b$; and if we put $f''(x)$ for the quotient arising from the division of $f'(x)$ by $x\mp b$, so that $f'(x)=(x\mp b)\,.f''(x)$, we shall have

$$f(x)=(x\mp a)\,.\,(x\mp b)\,.f''(x),$$

in which equation $f''(x)$ is a polynome of $n-2$ dimensions, or two degrees lower than $f(x)$.

It is evident we may continue to reason in the same manner either till, after successive divisions, we come at last to a binomial quotient, in which case the original polynome $f(x)$ will be completely resolved into binomial factors; or till we come to a quotient that has no roots,

in which case $f(x)$ will have no binomial factors except those previously found. We may therefore conclude that "a rational polynome has as many binomial factors as it has roots, and no more; every positive root producing a factor of the form $x-a$, and every negative root one of the form $x+a$; and since the number of binomial factors can never be greater than the dimensions of the polynome, its roots cannot exceed the same number."

4. There are very few cases in which it can be known immediately and by inspection that an equation has one or more roots. These cases depend upon the following propositions, viz. "If $\varphi(x)$ denote a rational polynome, having x, or some integral power of x, in every one of its terms, and likewise having the term that contains the greatest power of x positive, a value of x may be found that will make $\varphi(x)$ equal to any positive quantity, as s."

Suppose, first, that all the terms of $\varphi(x)$ are positive; then x^n being the first term, or that in which x rises to the highest power, if $s=t^n$, and $\lambda>t$, it is manifest that

$$\varphi(\lambda)>t^n>s.$$

Therefore, while x increases from 0 to be equal to λ, the function $\varphi(x)$ increases from 0 to be greater than s; and as the variations of $\varphi(x)$, however irregular they may be, are connected by the law of continuity, the function will pass through every gradation of magnitude between 0 and the greatest limit $\varphi(\lambda)$. Consequently, there is a value of x between 0 and λ, that will make $\varphi(x)$ equal to s.

When the terms of $\varphi(x)$ are not all positive, let all the positive terms except x^n be rejected, and all the negative terms be retained, and we shall have $\varphi(x)$ equal to, or greater than,

$$x^n-Fx^{n-i-1}-Hx^{n-i'-1}-, \text{ \&c.}$$

But, s being equal to t^n, we have

$$t^n=x^n-(x-t).\left\{x^{n-1}+tx^{n-2}+t^2x^{n-3}\ldots+t^{n-1}\right\}$$

Now, by equating the negative terms of the first expression to the terms containing the like powers of x in the value of t^n, we shall get

$$(x-t).t^i=F,\quad (x-t).t^{i'}=H, \text{ \&c.}$$

And hence,

$$x=t+\frac{F}{t^i},\quad x=t+\frac{H}{t^{i'}}, \text{ \&c.}$$

Let λ be either equal to or exceed the greatest of those values of x, then we shall have

$$\varphi(\lambda)>t^n>s.$$

Wherefore, as before, there is a value of x between 0 and λ, that will make $\varphi(x)$ equal to s.

From what has now been proved, we derive the following properties of equations.

1. "Every equation of odd dimensions has at least one positive root when the last term is negative, and one negative root when the last term is positive."

If the last term be negative, as in this instance,

$$x^{2n+1}+Ax^{2n}+Bx^{2n-1}\ldots+Mx-N=0;$$

according to what has been proved, a value of x, viz. a, may be found that will satisfy the condition,

$$a^{2n+1}+Aa^{2n}+Ba^{2n-1}\ldots+Ma=N;$$

then a is a positive root of the equation.

When the last term is positive, as in this equation,

$$x^{2n+1}+Ax^{2n}+Bx^{2n-1}\ldots+Mx+N=0,$$

change the sign of the last term, and the signs of all the terms that contain the even powers of x, then the polynome will become

$$x^{2n+1}-Ax^{2n}+Bx^{2n-1}\ldots+Mx-N:$$

and a value of x, viz. a, may be found such that

$$a^{2n+1}-Aa^{2n}+Ba^{2n-1}\ldots+Ma=N.$$

Now transpose N, and then change the signs of all the terms, and we shall get

$$-a^{2n+1}+Aa^{2n}-Ba^{2n-1}\ldots-Ma+N=0,$$

which shows that a is a negative root of the equation.

2. "Every equation of even dimensions having its last term negative, has two roots, one positive and one negative."

Let the equation be

$$x^{2n}+Ax^{2n-1}+Bx^{2n-2}\ldots+Mx-N=0;$$

and consider the polynomes,

$$x^{2n}+Ax^{2n-1}+Bx^{2n-2}\ldots+Mx-N,$$
$$x^{2n}-Ax^{2n-1}+Bx^{2n-2}\ldots-Mx-N,$$

in the latter of which the signs of all the terms containing the odd powers of x are changed; then there are two values of x, viz. a and b, such as to answer the conditions,

$$a^{2n}+Aa^{2n-1}\ldots+Ma=N$$
$$b^{2n}-Ab^{2n-1}\ldots-Mb=N:$$

consequently a is a positive and b a negative root of the equation.

3. "A polynome of even dimensions, which has no binomial factors, is always positive, whatever value be substituted for the unknown quantity."

Let the polynome be $f(x)$ or

$$x^{2n}+Ax^{2n-1}\ldots Mx+N;$$

then the last term, or that term which does not contain x, must be positive; for otherwise the polynome would have two roots and two binomial factors, contrary to the hypothesis. Now, if it be possible, let the polynome have a negative value when λ is substituted for x, so that $f(\lambda)=-P$; therefore, when $x=0$, $f(x)$ is equal to the positive quantity N; and, when $x=\lambda$, the same function is equal to $-P$; but since $f(x)$ passes through all degrees of magnitude between N and $-P$, while x varies from 0 to λ, it will become equal to zero when x has some intermediate value; therefore the polynome has one root between 0 and λ, and one binomial divisor corresponding to that root, contrary to the hypothesis.

It may be observed, that the converse of this proposition is not true; for a polynome of even dimensions, that has such factors as $(x-a)^2$, $(x-a)^4$, $(x-a)^{2m}$, may never become negative, although it is capable of being equal to zero.

5. The properties demonstrated in the last section lead to this general proposition relating to the number of roots in any equation, viz. "In any equation the number of all the roots is even when the dimensions are even, and odd when the dimensions are odd."

For every equation has as many binomial divisors as it has roots; and if we suppose an odd number of roots in an equation of even dimensions, or an even number in one of odd dimensions, the last quotient, after dividing successively by all the divisors, would be a polynome of odd dimensions, having at least one root, which would likewise be a root of the proposed equation. Therefore the number of all the roots of an equation cannot be even when the dimensions are odd, nor odd when the dimensions are even.

And again, since every polynome is equal to the continued product of all its binomial divisors, and the quotient last found, after dividing by them all successively, we obtain the following proposition, viz.: "Every rational polynome is equal either to the continued product of as many binomial factors as it has dimensions; or to the con-

tinued product of an even or odd number of such factors, according as the dimensions of the polynome are even or odd, and a polynome of even dimensions, which, having no binomial factors, is always positive, whatever value be substituted for the unknown quantity."

Equal roots.

6. When several of the binomial factors of an equation are equal to one another, it is said to have so many equal roots. In this case the equation can be divided a number of times successively by the same binomial divisor. Thus, an equation which is twice divisible by $x-a$, or, which is the same thing, once by $(x-a)^2$, has two roots equal to a; and if it can be divided by $(x-a)^m$, it has m roots equal to a.

The most obvious way of finding the conditions on which the equality of the roots depends would therefore be to expand the divisor $(x-a)^m$ by the binomial theorem, and then divide the equation by it; for, after the integral quotient is obtained, the required conditions will be found by making the several parts of the remainder separately equal to zero. The number of the conditions found in this manner is equal to the exponent of the divisor; for of so many parts will the remainder of the division consist. But, in a complex operation, it is difficult to ascertain the remainder; and, besides, it is not necessary to consider all the equations obtained by this process, because both the number and the value of the equal roots can be found by means of two of them only.

The inconveniences just mentioned will be avoided by proceeding in the following manner: Let the equation be

$$x^n + Ax^{n-1} + Bx^{n-2} \ldots + Mx + N = 0;$$

then, if it be divisible by $(x-a)^m$, the quotient will be a polynome of $n-m$ dimensions; and we may therefore suppose that the expression

$$x^n + Ax^{n-1} + Bx^{n-2} \ldots + Mx + N$$

is equal to the product,

$$(x-a)^m \times \{x^{n-m} + A'x^{n-m-1} + B'x^{n-m-2} +, \&c.\}.$$

In these expressions, x may have any value whatever; and therefore the equality between them will still subsist if we substitute $x+i$ for x, i being any arbitrary number; therefore the expression

$$(x+i)^n + A(x+i)^{n-1} + B(x+i)^{n-2} \ldots + M(x+i) + N$$

will be equal to the product

$$(x-a+i)^m \times \{(x+i)^{n-m} + A'(x+i)^{n-m-1} +, \&c.\}.$$

Now, let the several powers of $(x+i)$ be expanded by the binomial theorem, and put

$$X = x^n + Ax^{n-1} + Bx^{n-2} \ldots + Mx + N,$$

$$Y = nx^{n-1} + (n-1)Ax^{n-2} + (n-2)Bx^{n-3} \ldots + M,$$

$$Z = n\frac{n-1}{2}x^{n-2} + (n-1)\frac{n-2}{2}Ax^{n-3} +, \&c.$$

$$V = n\frac{n-1}{2}\cdot\frac{n-2}{3}x^{n-3} + (n-1)\cdot\frac{n-2}{2}\cdot\frac{n-2}{3}Ax^{n-4} +, \&c. \quad \&c. \quad \&c.$$

then the given polynome of n dimensions will become

$$X + Yi + Zi^2 + Vi^3 +, \&c. \qquad (A).$$

And if the like operations are performed in the polynome of $n-m$ dimensions, and $(x-a+i)^m$ be expanded by the binomial theorem, the product of these two expressions will become

$$\left\{(x-a)^m + m.(x-a)^{m-1}i + m.\frac{m-1}{2}.(x-a)^{m-2}i^2 +, \&c.\right\} \times \left\{X' + Y'i + Zi^2 +, \&c.\right\}. \qquad (B).$$

The expression (A) being equal to the product (B), whatever i stands for, the co-efficients of the like powers of i must be equal; and hence, by equating the terms in which i is wanting, and likewise the terms that contain the first power of i, we get

$$X = (x-a)^m X'$$

$$Y = (x-a)^m Y' + m(x-a)^{m-1}X';$$

which proves that $(x-a)^{m-1}$ is a common divisor of X and Y. If, therefore, by means of the usual process, we seek the greatest common measure of the two polynomes X, Y, or,

$$x^n + Ax^{n-1} + Bx^{n-2} \ldots\ldots + Mx + N,$$

$$nx^{n-1} + (n-1)Ax^{n-2} + (n-2)Bx^{n-3} \ldots + M;$$

we shall obtain the factor $(x-a)^{m-1}$, and the given polynome X will be divisible by $(x-a)^m$; that is, it will contain the common factor $x-a$ once more than the polynome Y contains it.

If we proceed farther, and equate the co-efficients of i^2 in the expressions (A) and (B), we shall get

$$Z = (x-a)^m Z' + m(x-a)^{m-1}Y' + m.\frac{m-1}{2}(x-a)^{m-2}X';$$

which shows that Z is divisible by $(x-a)^{m-2}$. In the same manner, it may be proved, that V is divisible by $(x-a)^{m-3}$, and so on. It appears, therefore, that the first m co-efficients of the expression (A) are respectively divisible by $(x-a)^m$, $(x-a)^{m-1}$, $(x-a)^{m-2}$, &c.; and consequently we shall have

$$X = 0,\ Y = 0,\ Z = 0,\ V = 0, \&c.$$

when the common root a is substituted for x.

If the polynome X is divisible by $\{(x-a)^2 + \beta^2\}^n$, it may be proved in like manner that $\{(x-a)^2 + \beta^2\}^{n-1}$ will be a common divisor of X and Y.

We may therefore lay down the following rule for finding all the double, triple, &c. divisors of any given polynome X: "Find R, the greatest common measure of X and Y, and resolve it into its elementary factors; then each of these factors will be contained in X once more than in R."

Number of positive and negative roots.

7. If it be required to find how many of the roots of an equation are positive, and how many are negative, we have for this purpose the rule first published in the *Geometry* of Descartes. This celebrated rule seems to have been discovered by induction; at least its author gave no demonstration of it, and disputes arose about its true import. It was demonstrated for the first time by Du Gua, in the *Mémoires de Paris;* but many other demonstrations of it have since appeared, of which that of Segner, in the *Mémoires de Berlin*, 1756, is not only the most simple, but probably the most simple that will ever be invented.

Segner deduced the rule of Descartes from the following analytical proposition, viz.

"If any rational polynome be multiplied by $x-a$, the changes from one sign to another, from $+$ to -1, and from $-$ to $+1$, will be at least one more in the product than in the given polynome; and if it be multiplied by $x+a$, the successions of the same sign, of $+$ to $+1$, and of $-$ to -1, will be at least one more."

Let the proposed polynome be

$$x^n \pm Ax^{n-1} \pm Bx^{n-1} \ldots\ldots \pm Mx \pm N;$$

then, according to the usual process, the product of the polynome by $x-a$ will be found by adding these two lines, viz.

$$\left.\begin{array}{l} x^{n+1} \pm Ax^n \pm Bx^{n-1} \ldots \pm Mx^2 \pm Nx \\ \quad -ax^n \mp Aax^{n-1} \ldots \mp Lax^2 \mp Max \mp Na \end{array}\right\}$$

the signs of the several terms remaining unchanged in the first line, and being all changed in the second line. It is

 evident, therefore, that the terms of the product will have the same signs with the respective terms of the proposed polynome, except when a co-efficient in the second line is greater than the one above it, and likewise has a contrary sign; the sign of the last term of the product being always the same with the sign of the last term of the second line. Now, beginning on the left hand, pass over the terms of the first line, so long as they have the same signs with the terms of the product. When this ceases to be the case, the signs in the product will be the same as in the second line, and contrary to those in the first line; wherefore descend to the second line, and pass along its terms till the signs in the product are again the same as those in the first line, and then ascend to that line. Continue thus descending and ascending alternately till all the terms in both lines are taken in. At the conclusion, it is evident that the descendings are always one more than the ascendings, because the passing from one line to another both begins and ends with descending.

If we descend from $\pm Ax^n$ in the first line, to $\mp Aax^{n-1}$ in the second line, it is evident that the signs of $\pm Ax^n$ and $\pm Bx^{n-}$ in the first line will be the same, both being contrary to the sign of $\mp Aax^{n-1}$ in the second line. Therefore, in the given polynome, the first and second terms have the same sign. But in the product the like terms have contrary signs; for the second term of the product has the same sign with $\pm Ax^n$ in the first line, and the third term of the product has the same sign with $\mp Aax^{n-1}$ in the second line. Thus it appears that a variation from one sign to another is introduced in the product, instead of a continuation of the same sign that takes place in the given polynome; and the same thing will happen at every descending.

In ascending from the second line to the first, there may either be a continuation of the product instead of a variation in the given polynome, or the contrary; but one of these two must take place.

Now, so long as we keep on the first line, the signs in the product are the same with those of the given polynome; and, so long as we keep on the second line, the signs in the product are contrary to those in the polynome. In both cases, therefore, the variations from + to — 1, and from — to + 1, are the same in the product and in the polynome. Every descending introduces a variation in the product, instead of a continuation that takes place in the polynome; and although it be supposed that every ascending introduces a continuation in the product instead of a variation that exists in the polynome, yet, on the whole, the variations introduced must be one more than the continuations, because the descendings are one more than the ascendings.

Again, if the given polynome be multiplied by $x + a$, the product will be the sum of these two lines, viz.

$$\left.\begin{array}{l} x^{n+1} \pm Ax^n \pm Bx^{n-1} \ldots \pm Mx^2 \pm Nx \\ \quad + ax^n \pm Aax^{n-1} \quad \pm Lax^2 \pm Max \pm Na. \end{array}\right\}$$

Here the terms of both lines have the same signs; and, as before, the signs in the product will be the same with the signs of the proposed polynome, unless when a co-efficient in the second line is greater than the one above it, and likewise has a contrary sign; the sign of the last term of the product being always the same with the sign of the last term in the second line. Now, if we pass along all the terms of both lines, descending from the first line to the second, when the signs in the product change from being the same with those in the given polynome, to be contrary to them; and ascending from the second line to the first, when the signs in the product change from being contrary to those in the polynome, to be the same with them; it is evident that the descendings will be one more than the ascendings, as in the former case.

If we descend from $\pm Ax^n$ in the first line, to $\pm Aax^{n-1}$ in the second line, the two terms $\pm Ax^n$ and $\pm Bx^{n-1}$ in the first line will have different signs; for on account of the descending, $\pm Bx^{n-1}$ has a contrary sign to the term $\pm Aax^{n-1}$ below it, and, consequently, to $\pm Ax^n$ in the first line. Therefore the second and third terms in the polynome have different signs. But the like terms in the product have the same sign; for the second term in the product has the same sign with $\pm Ax^n$ in the first line; and the third term of the product has the same sign with $\pm Aax^{n-1}$ in the second line. Thus there is a continuation of the same sign introduced in the product, instead of a variation from one sign to another that takes place in the polynome; and the same thing is true at every descending.

In ascending from the second line to the first, there may either be a variation in the product instead of a continuation that exists in the polynome, or the contrary. But one of these two must take place.

Now it is evident that, except at the descendings and ascendings, there is the same number of continuations of the same sign, and the same number of variations from one sign to another, in the product and in the given polynome. Every descending introduces a continuation in the product instead of a variation existing in the polynome. And even if we suppose that every ascending introduces a variation in the product instead of a continuation that takes place in the polynome, yet, on the whole, there will be one continuation more in the product than in the polynome, because the descendings are one more than the ascendings.

In the preceding demonstration, it is supposed that all the ascendings have a contrary effect to the descendings, by which means there is introduced in the product the least possible number of variations from one sign to another in the one case, and the least possible number of continuations of the same sign in the other. But if, in the first case, we suppose that, at one ascending, there is a variation in the product, and a continuation in the polynome, this will add one to the variations in the product, and one to the continuations in the polynome; so that the variations in the product will now exceed those in the polynome by three, namely, by two more than in the circumstances supposed in the demonstration. And if we extend the like reasoning to two, three, &c. ascendings, the variations in the product will exceed those in the polynome respectively by five, seven, &c. The like conclusion is evidently true of the second case, *mutatis mutandis;* and hence the preceding proposition, when it is generalized as much as it can be, may be thus enunciated: "If any rational polynome be multiplied by $x - a$, the variations from one sign to another in the product will exceed those in the polynome by one, or three, or five, or by some odd number; and if it be multiplied by $x + a$, the continuations of the same sign in the product will exceed those in the polynome by one, or three, or five, or by some odd number."

Now, if we conceive that any rational polynome is resolved into its binomial factors, there will be a factor of the form $x - a$ for every positive root, and one of the form $x + a$ for every negative root; and when all the factors are multiplied together in order to reproduce the polynome, it follows, from what has been proved, that the product will contain at least one change from + to —, or from — to + 1, for every factor of the form $x - a$, or for every positive root; and at least one succession of + to +, or of — to — 1, for every factor of the form $x + a$, or for every negative root. Hence this rule, viz. "An

Equations. equation cannot have more positive roots than it has variations from one sign to another, nor more negative roots than it has continuations of the same sign."

In general, this rule merely points out limits which the number of the positive and negative roots of an equation cannot exceed. But it gives no criterion by which we can certainly know that an equation has even one positive or one negative root, much less does it ascertain the exact number of each kind.

But if the proposed equation can be completely resolved into real binomial factors; in which case the total number of its roots will be equal to its dimensions, and consequently to the sum of all the variations from one sign to another, and of all the continuations of the same sign; it is evident that the number of the positive roots will be precisely equal to that of the variations, and the number of the negative roots precisely equal to that of the continuations. In this case, therefore, and in this case only, the rule of Descartes is perfect, ascertaining the exact number of each kind of roots in the proposed equation.

We subjoin some consequences that result from the principles laid down.

"If a polynome $f(x)$ of n dimensions be multiplied by $x-a$, or $x+a$; and, in the first case, if the number of variations from one sign to another be augmented by the odd number $2i+1$; or, in the second case, if the number of continuations of the same sign be augmented by $2i+1$; then the total number of the roots, positive and negative, of the proposed polynome, cannot be greater than $n-2i$."

For, when the multiplier is $x-a$, let m denote the number of the variations from one sign to another in the proposed polynome $f(x)$; then $m+2i+1$ will be the total number of variations in the product $(x-a)\times f(x)$; consequently the total number of continuations in $(x-a)\times f(x)$ will be equal to $(n+1)-(m+2i+1)$, or $n-m-2i$. But a polynome cannot have more negative roots than it has continuations of the same sign; wherefore the number of the negative roots of $(x-a)\times f(x)$ cannot be greater than $n-m-2i$. Now, the two polynomes $f(x)$ and $(x-a)\times f(x)$ have the same negative roots; and hence the number of the negative roots of $f(x)$ cannot exceed $n-m-2i$. But the number of the positive roots of $f(x)$ cannot exceed m; consequently the total number of the roots of $f(x)$ cannot be greater than $m+n-m-2i$; that is, than $n-2i$. And the proposition may be demonstrated in a similar manner when the multiplier is $x+a$.

"If one or several consecutive terms of an equation be wanting, and if the next terms on each side of those wanting have the same sign, the equation cannot have as many roots as it has dimensions."

Let the equation be $P+Q=0$, P and Q denoting the two parts on each side of the terms wanting. Having multiplied $P+Q$ by $x-a$, the product will be $(x-a)P+(x-a)Q$; and it is evident that we may consider P, Q, $(x-a)P$, $(x-a)Q$ as separate polynomes; hence, in each of the polynomes $(x-a)P$ and $(x-a)Q$, there will be at least one more variation from one sign to another than there is in P and Q. Again, in the polynome $P+Q$, there will be a continuation of the same sign in passing from P to Q; because the last term of P is supposed to have the same sign with the first term of Q. On the other hand, because the last term of $(x-a)P$ has a contrary sign to the last term of P; and the first term of $(x-a)Q$, the same sign with the first term of Q, it follows that, in the polynome $(x-a)P+(x-a)Q$, there will be a variation from one sign to another in passing from $(x-a)P$ to $(x-a)Q$. Therefore, on the whole, there will be at least three variations from one sign to another in $(x-a)P+(x-a)Q$, more than there is in $P+Q$. Consequently, by the last proposition, the number of all the roots of the proposed equation must be at least two less than its dimensions.

Number of real roots in an equation.

8. An important inquiry is, to find how many roots, that is, real roots, there are in any proposed equation. Much has been written on this subject, but not very successfully. No general method has been found that is practically useful. Many *criteria* have been contrived, by means of which we can certainly discover that roots are wanting in an equation, although we cannot infer the existence of the roots when the same criteria fail. But great value cannot be attached to such rules, since they are neither sufficient guides in practice, nor have much tendency to throw light on the theory.

Waring first, and nearly about the same time Lagrange, proposed a method which is successful in finding the conditions necessary in order that an equation have as many roots as it has dimensions, and which in all cases points out a limit that the number of the roots cannot exceed. This is effected by an auxiliary equation, and merely by the signs of its co-efficients, without requiring the computation of any of its roots. This procedure answers very well for equations of the third and fourth degrees; and it has even been extended by Waring to those of the fifth degree; but in this last case the calculation is very long, and would be altogether impracticable in the higher orders of equations. It is also not a little probable that this rule employs more conditions than are absolutely necessary for determining the point in question; there being great reason to think that some of them are implied in the rest, and are deducible from them. The method here alluded to depends upon the theory of trinomial divisors; and as it is much referred to by algebraists of the present day, we shall, in a subsequent part of this article, briefly explain the principles on which it is founded.

There is also another way of finding the number of real roots in an equation, which is general for all orders, and requires the solution of such equations only as are of lower dimensions than the one proposed. As to practical utility, indeed, this method is of little avail in equations passing the third and fourth degrees, or at most the fifth degree; but it is nevertheless not without interest, both because it is founded on the principles essential to the inquiry, and because it leads to some useful properties. Algebraists differ from one another in their exposition of this method. Some derive it from the theory of Harriot, namely, that every rational polynome is the product of as many binomial factors as it has dimensions; in which manner of proceeding the impossible roots are the occasion of uncertainty and embarrassment. Others, again, deduce it from the variations of magnitude which a rational polynome undergoes when the unknown quantity is made to pass through all possible degrees of increasing and decreasing. This last mode of investigation seems greatly to deserve the preference, being in reality the only one that is entirely unexceptionable, and requires no principles foreign to the research.

Suppose an equation, $x^n+Ax^{n-1}+Bx^{n-2}\ldots\ldots+Mx+N=0$, which we may denote by $f(x)=0$: substitute $x-i$ in place of x, and put

$$X=f(x)=x^n+Ax^{n-1}\ldots\ldots+Mx+N,$$
$$X'=nx^{n-1}+(n-1)Ax^{n-2}+(n-2)Bx^{n-2}\ldots+M,$$
$$X''=n\cdot\frac{n-1}{2}x^{n-2}+(n-1)\cdot\frac{n-2}{2}Ax^{n-3}+,\ \&c.\ \&c.$$

then the function $f(x-i)$ will be transformed into

$$X-X'.i+X''.i^2-X'''.i^3+,\ \&c.$$

If we suppose the notation of the differential calculus, the same transformation will be thus represented:

$$f(x)-\frac{d.f(x)}{dx}\cdot i+\frac{1}{2}\cdot\frac{d^2.f(x)}{dx^2}\cdot i^2-, \&c.;$$

which has the advantage of pointing out in what manner the several functions, X′, X″, &c. are derived from one another, and from the first function X, or $f(x)$.

Let α, β, γ, &c. denote the real roots of the equation $X=0$, or $f(x)=0$, arranged according to the order of their magnitude, that is, α greater than β, β greater than γ, and so on. In like manner, observing the same order of arrangement, let α', β', γ', &c. represent the roots of $X'=0$, or $\frac{d.f(x)}{dx}=0$; and, for the sake of simplicity, suppose that the equation $X'=0$ has no equal roots.

The relations which the variations of the polynome X bear to the variations of x, depend upon the functions X′, X″, &c. and principally upon the first of these. If X′ be positive, X will decrease as x decreases; if X′ be negative, X will increase as x decreases; and if X′ pass from being positive to become negative, or the contrary, then x continuing to decrease, X will change from decreasing to increasing, or the contrary; that is, it will attain a minimum or a maximum value. What is here said is the foundation of the method taught in the differential calculus, for finding the maxima and minima of algebraic quantities.

Now, when x has a value great enough, the polynome X′ will have the same sign with its first term, that is, it will be positive; and it will continue positive so long as x is greater than α', the greatest root of the equation $X'=0$; after which it will become negative. Hence, while x decreases to the limit α', the polynome $f(x)$, which is positive when x is sufficiently great, will continually decrease; and when $x=\alpha'$, $f(x)$ will pass from decreasing to increasing, or it will have a minimum value. Now if this minimum $f(\alpha')$ be positive, $f(x)$ has not decreased to zero, and the given equation will have no root greater than α'. If $f(\alpha')=0$, then, because the two equations $X=0$ and $X'=0$, take place at the same time, the given equation will have two roots equal to α'. (Sect. 6.) *Lastly*, if $f(\alpha')$ be negative, the polynome $f(x)$ has decreased from being positive to be negative; and therefore it has passed through zero, and the given equation will have one root, viz. α greater than α'.

As x continues to decrease from α' to β', the polynome X′ being negative, $f(x)$ will continually increase. At the limit $x=\beta'$, X′ is first equal to zero, and then becomes positive; and $f(x)$ will therefore change from increasing to decreasing, or will attain a maximum value. If this maximum $f(\beta')$ be negative, the polynome $f(x)$ has not increased to zero, and the given equation will have no root between α' and β': if $f(\beta')=0$, it will have two roots equal to β: and if $f(\beta')$ be positive, $f(x)$, in increasing from the negative quantity $f(\alpha')$ to the positive quantity $f(\beta')$, must have passed through zero, and the given equation will have one root, viz. β, between α' and β'.

In like manner, x continuing to decrease from β' to γ', the polynome $f(x)$ will decrease from the maximum $f(\beta')$ to the minimum $f(\gamma')$: if $f(\gamma')$ be positive, the proposed equation will have no root between β' and γ'; if $f(\gamma')=0$, it will have two roots equal to γ'; and if $f(\gamma')$ be negative, it will have one root, viz. γ, between the limits β' and γ'.

As the function $f(x)$ must become a minimum or a maximum, or must pass from decreasing to increasing, or the contrary, between every two contiguous roots of the equation $f(x)=0$; and as the limits where the changes take place are determined by the roots of the equation $X'=0$; it follows that there must be at least one root of this last equation between every two contiguous roots of the first. Hence the equation $f(x)=0$ cannot have as many roots as dimensions, unless the equation $X'=0$ likewise have as many roots as dimensions; and in general we have this rule, which determines a limit that the number of the roots of an equation cannot surpass, although it may fall short of it: "The roots of an equation $f(x)=0$ cannot exceed in number those of the equation $\frac{df(x)}{dx}=0$, by more than one."

But if we can find the roots of the equation $X'=0$, which is always one degree lower than the proposed equation, we can thence discover exactly both the number and the limits of the roots of this last. For let α', β', γ', &c. be substituted in the polynome $f(x)$, and let the results be arranged in order, viz.

$$\underset{-}{f(\alpha')},\underset{+}{f(\beta')},\underset{-}{f(\gamma')},\underset{+}{f(\delta')}, \&c.:$$

if these quantities are alternately negative and positive; the first, third, fifth, &c. which are all minima, having the sign *minus;* and the second, fourth, &c. which are all maxima, having the sign *plus;* then the proposed equation $f(x)=0$ will have just one root more than the equation $X'=0$. When some of the conditions fail, the roots of the proposed equation will fall short of the number specified. If one maximum have the sign *minus*, or one minimum the sign *plus*, two roots will be wanting in the proposed equation; and in general as many roots will disappear, as there are consecutive minima and maxima that have the same sign deducting one; unless the minima and maxima precede the greatest root, or come after the least root, in which cases there will be as many roots wanting as there are minima and maxima that have the same sign.

Since the series of functions, X, X′, X″, &c. are derived similarly from one another, we may prove, as has been done with respect to the two first, that the roots of any one are contained between the roots of that which follows it. Hence, if the given equation have as many roots as dimensions, every equation in the series will likewise have as many roots as dimensions; and if there be roots wanting in any one, there will be at least as many wanting in every equation preceding it in the series.

The connected equations necessarily terminate in one of the first degree, which gives a limit between the two roots of the quadratic immediately before it; in like manner, the roots of the quadratic are the limits of the roots of the cubic preceding it; and in this manner, by going through all the successive equations, we shall finally arrive at the limits of the roots of the proposed equation. This process has been called *La Methode des Cascades;* but the length of the calculations renders it useless in practice.

The procedure explained above would enable us to find the number of roots in an equation of any order, if we were in possession of rules for solving equations of the inferior degrees. For want of such rules, the practical advantage that can be derived from it is very limited. Mathematicians have therefore turned their attention to determine the point in question in a way that should not require the resolution of equations. They have sought to investigate rational functions of the co-efficients, which, by means of the signs they are affected with in every particular case, might indicate the number of roots the equation possesses. Of this nature is the method which Du Gua has given in the *Mémoires de Paris*, 1741, for finding the conditions necessary in order that an equation have as many roots as dimensions. By a process analogous to that of Du Gua, M. Cauchy, in an excellent *Me-*

moir, published in the sixteenth volume of the *Journal de l'Ecole Polytechnique*, has shown not only that the total number of the roots may in every case be discovered, but likewise that the numbers of the positive and negative roots may be separately ascertained. The principles of both these methods are to be found in the theory explained above; but as many considerations of some intricacy are involved in them, a particular account of them would exceed the limits of this article.

In what goes before, we have supposed that all the roots of the equation $X' = 0$ are unequal; and in order to complete the theory, it remains to notice the consequences that follow when the case is otherwise. Suppose, then, that $X' = (x-\lambda)^i \times Q$: And, in the first place, if λ be a root of the equation $f(x) = 0$, there will in reality be no exception to the general conclusion; because in this case it is known that the polynome $f(x)$ will be divisible by $(x-\lambda)^{i+1}$. (Sect. 6.) Now, the case just mentioned being set aside, if i be an even number, the polynome X', or $(x-\lambda)^i \cdot Q$, will be equal to zero when $x = \lambda$; but it will not change its sign when x, from being less, comes to be greater than λ. Hence the polynome $f(x)$ will neither attain a maximum nor a minimum value at the same limit; and it will have no root, either between λ and the next greater root of the equation $X' = 0$, or between λ and the next less root of the same equation. It appears, therefore, that when i is even, the number of the roots of the equation $f(x) = 0$, and their limits, will depend entirely upon the equation $Q = 0$. Again, when i is an odd number, the polynome X' will be equal to zero when $x = \lambda$, and it will likewise change its sign when x is taken on contrary sides of that limit: Consequently, when $x = \lambda$, the polynome $f(x)$ will be a maximum or a minimum; and the nature of its roots will depend upon the equation $(x-\lambda)\, Q = 0$. It is evident that we may extend the same conclusions to any two adjacent equations in the series,

$$X = 0,\ X' = 0,\ X'' = 0,\ X''' = 0, \ \&c.$$

provided the one which stands lower in the series is reducible to the form $(x-\lambda)^i Q$; and that $x-\lambda$ is not a common divisor of both. We may likewise draw this general inference from the principles that have been explained, viz. "If, in the series of connected equations, any one be found which is divisible by $(x-\lambda)^{2i}$, or $(x-\lambda)^{2i+1}$, at the same time that $x-\lambda$ is not a divisor of the equation immediately preceding, there will be at least $2i$ roots wanting in this last equation, and in all that stand before it in the series."

The following not inelegant proposition is a consequence of what has just been proved: "The number of the roots of an equation of n dimensions, in which $2i$ or $2i+1$, consecutive terms, are wanting, cannot be greater than $n-2i$."

Let the equation be represented by

$$P + Q = 0;$$

supposing that $2i$, or $2i+1$ terms, are wanting between P and Q. Therefore, if the first term of Q contain x^m, the last term of P will contain x^{m+2i+1}, or x^{m+2i+2}. Now, in the series of equations, we shall at length arrive at one from which all the quantities of Q are exterminated; which equation, if we use the notation of the differential calculus, is equivalent to

$$\frac{d^{m+1}P}{dx^{m+1}} = 0;$$

and it is divisible by x^{2i}, or x^{2i+1}: And as the one immediately preceding it in the series, viz.

$$\frac{d^mP}{dx^m} + \frac{d^mQ}{dx^m} = 0,$$

is not divisible by x, it follows, from what has been shown, that there will be at least $2i$ roots wanting in this last equation, and in all those that stand before it; consequently the proposed equation cannot have more than $n-2i$ roots.

From this we learn that it is not always possible, at least by any operations with real quantities, to transform an equation into another in which any proposed number of the intermediate terms shall be wanting. For the terms to be taken away may be such that the transformed equation could not have the same number of real roots as the one given; but it is impossible, without introducing imaginary quantities, to transform an equation with a certain number of real roots into another with a different number of such roots.

9. In what goes before, we have sought for the roots and binomial divisors in the nature of the polynome. We are now to take an inverted view of the subject, and to consider a rational polynome as produced by the continued multiplication of as many binomial factors as it has dimensions; from which source there arises an interesting set of properties.

If we take the words root and binomial factor strictly in the sense in which we have hitherto used them, and as denoting real quantities only, nothing is more certain than that all polynomes cannot be generated by binomial factors. But it will afterwards be proved that every rational polynome can be completely exhausted by binomial and trinomial divisors; and if we admit the resolution of every trinomial divisor into two imaginary factors, we shall arrive, with all the rigour of which the investigation is capable, at the genesis of equations supposed by Harriot, which represents them as entirely composed of binomial factors, possible or impossible. Besides, in extending to all equations the conclusions obtained from the manner of generating them, it may be observed that the properties so obtained, being ultimately expressed in functions of the co-efficients from which the roots and generating factors have disappeared, are in a manner independent of the method of investigation. Such is the structure of the language of algebra, that the conclusions to which it leads, although deduced by reasoning from a hypothesis not strictly general, are nevertheless true in all cases, when they are finally disengaged from what is peculiar in the analysis.

Suppose a polynome, as

$$x^n - A^{(1)}x^{n-1} + A^{(2)}x^{n-3} \ldots \pm A^{(n-1)}x \mp A^{(n)},$$

which is produced by the multiplication of the n factors,

$$(x-\alpha)\cdot(x-\beta)(x-\gamma)(x-\delta), \ \&c.$$

then, by actually multiplying the factors, and equating the like terms of the equivalent expressions, we shall get

$$A^{(1)} = \alpha + \beta + \gamma + \delta +, \&c.$$
$$A^{(2)} = \alpha\beta + \alpha\gamma +, \&c. + \beta\gamma +, \&c.$$
$$A^{(3)} = \alpha\beta\gamma + \alpha\beta\delta +, \&c. + \beta\gamma\delta +, \&c.$$
$$A^{(4)} = \alpha\beta\gamma\delta +, \&c.$$
&c.

Hence it appears that the co-efficient of the second term of the polynome, or $-A^{(1)}$, is equal to the sum of all the roots with their signs changed; the co-efficient of the third term, or $+A^{(2)}$, to the sum of all the products of every two roots; the co-efficient of the fourth term,

or $-A^{(3)}$, to the sum of all the products of every three roots with their signs changed, and so on, the signs of the roots being always changed in the products of an odd number; and finally, the last term is the product of all the roots with their signs changed or not, according as their number is odd or even.

It is evident that the ultimate product of the binomial factors will always be the same, in whatever order they are multiplied; and hence the co-efficients of the polynome will consist of the same products, however the roots be interchanged among one another. Expressions of the kind just mentioned, which have constantly the same value, whatever change is made in the order of the quantities they contain, are called *invariable functions* and *symmetrical functions.* The co-efficients of an equation are the most simple symmetrical functions of the roots, from which it may be required, on the one hand to deduce all other functions of the like kind, and on the other to go back to the roots themselves. Most inquiries relating to equations are connected with one or other of these two problems; of which the first, like most direct methods, is attended with little difficulty, and has been completely solved; while the other, past equations of the fourth degree, has eluded all the attempts of algebraists.

After the co-efficients of the polynome, the next most simple symmetrical functions of the roots are the sums of the squares, cubes, &c. In the universal arithmetic of Sir Isaac Newton, a very elegant rule is given for computing the sum of any proposed powers of the roots; and as this rule is a fundamental point in the theory of equations, we subjoin an elementary investigation of it.

Of the binomial factors before set down, let the first $x-\alpha$ be left out, and having multiplied the rest together, let the product be

$$x^{n-1}-\varphi^{(1)}x^{n-2}+\varphi^{(2)}x^{n-3}-\varphi^{(3)}x^{n-4}+,\&c.;$$

in which expression $\varphi^{(1)}$ is the sum of all the roots β, γ, δ, &c. except the first α; $\varphi^{(2)}$ is the sum of the products of every two of them, and so on. Now, multiply by $x-\alpha$, and the product will be equivalent to the given polynome: hence we get

$$\begin{aligned}
A^{(1)}&=\alpha+\varphi^{(1)},\\
A^{(2)}&=\alpha.\varphi^{(1)}+\varphi^{(2)},\\
A^{(3)}&=\alpha.\varphi^{(2)}+\varphi^{(3)},\\
&\vdots\\
A^{(r)}&=\alpha.\varphi^{(r-1)}+\varphi^{(r)}.
\end{aligned}$$

Again, multiply these formulæ in order by α^{r-1}, α^{r-2}, α^{r-3}, &c.; then

$$\begin{aligned}
\alpha^r&=\alpha^r,\\
A^{(1)}.\alpha^{r-1}&=\alpha^r+\alpha^{r-1}.\varphi^{(1)},\\
A^{(2)}.\alpha^{r-2}&=\alpha^{r-1}.\varphi^{(1)}+\alpha^{r-2}.\varphi^{(2)},\\
&\vdots\\
A^{(r-1)}.\alpha&=\alpha^2\varphi^{(r-2)}+\alpha.\varphi^{(r-1)},\\
A^{(r)}&=\alpha.\varphi^{(r-1)}+\varphi^{(r)};
\end{aligned}$$

and, by adding and subtracting alternately, we get

$$\alpha^{(r)}-A^{(1)}.\alpha^{r-1}+A^{(2)}.\alpha^{r-2}\ldots\pm A^{(r-1)}.\alpha \mp A^{(r)}=\mp\varphi^{(r)},$$

in which expression $\varphi^{(r)}$ is the sum of all the products of r dimensions of the roots β, γ, δ, &c. leaving out the first α.

In like manner, if we leave out the factor $x-\beta$, and multiply all the rest, and proceed as before, we shall get

$$\beta^r-A^{(1)}\beta^{r-1}+A^{(2)}\beta^{r-2}\ldots\pm A^{(r-1)}\beta\mp A^{(r)}=\pm\varphi'^{(r)},$$

the symbol $\varphi'^{(r)}$ being the sum of the products of r dimensions of all the roots, α, γ, δ, except the second β.

And if we next leave out the factor $x-\gamma$, and follow a like procedure, we shall get

$$\gamma^r-A^{(1)}.\gamma^{r-1}+A^{(2)}.\gamma^{r-2}\ldots\pm A^{(r-1)}.\gamma\mp A^{(r)}=\mp\varphi''^{(r)};$$

where $\varphi''^{(r)}$ represents the sum of the products of r dimensions of all the roots α, β, δ, &c. except the third γ.

If we proceed similarly till every one of the n factors is left out in its turn, and then add all the results, we shall get

$$S_r-A^{(1)}S_{r-1}+A^{(2)}S_{r-2}\ldots\pm A^{(r-1)}S_1 \mp nA^{(r)}=\mp\left\{\varphi^{(r)}+\varphi'^{(r)}+\varphi''^{(r)}+,\&c.\right\};$$

in which expression S_r is written for the sum of the r powers of the roots; S_{r-1} for the sum of the $(r-1)$ powers, and so on.

Every product in any one of the aggregate quantities $\varphi^{(r)}, \varphi^{(r)}, \varphi''^{(r)}$, &c., is found in $A^{(r)}$, which is the sum of the products of r dimensions of all the roots; and hence it is easy to perceive that the sum of all the aggregates must be a multiple of $A^{(r)}$. Take any product in $A^{(r)}$; then that product will not be contained in r of the quantities $\varphi^{(r)}, \varphi'^{(r)}, \varphi''^{(r)}$, &c.; because, in so many of them, one or other of the letters of the product will be wanting; but the same product will be contained once in every one of the $n-r$ remaining quantities, because in every one of these all the letters of the product will be contained. Every product in $A^{(r)}$ is therefore repeated $n-r$ times in the sum of the quantities $\varphi^{(r)}, \varphi'^{(r)}, \varphi''^{(r)}$, &c.; consequently,

$$\varphi^{(r)}+\varphi'^{(r)}+\varphi''^{(r)}+,\&c.=(n-r)A^{(r)}.$$

Substitute this value in the formula obtained above, and after transposing and cancelling $nA^{(r)}$, which appears with contrary signs, we shall get

$$S_r-A^{(1)}S_{r-1}+A^{(2)}S_{r-2}\ldots\pm A^{r-1}S \mp rA^{(r)}=0.$$

This is the rule of Sir Isaac Newton, and contains all his particular formulæ, as will readily appear by putting 1, 2, 3, &c. successively for r.

The preceding formula will enable us to compute, in succession, the sums of all the positive powers of the roots, both when r is less and when it is greater than the dimensions of the equation. But, in applying the formula in the latter case, we must observe that all the co-efficients of the polynome after $A^{(r)}$ are wanting, or equal to nothing.

If, in the first step of the preceding investigation, we take the co-efficients that follow $A^{(r)}$, we shall get

$$\begin{aligned}
A^{(r+1)}&=\alpha.\varphi^{(r)}+\varphi^{(r+1)},\\
A^{(r+2)}&=\alpha.\varphi^{(r+1)}+\varphi^{(r+2)},
\end{aligned}$$

$$A^{(n-1)} = \alpha\varphi^{(n-2)} + \varphi^{(n-1)},$$
$$A^{(n)} = \alpha \cdot \varphi^{(n-1)}.$$

And, by first dividing by α, α^2, α^3, &c. in order, and then subtracting and adding alternately, we shall obtain

$$\frac{A^{(r+1)}}{\alpha} - \frac{A^{(r+2)}}{\alpha^2} + \frac{A^{(r+3)}}{\alpha^3} -, \&c. = \varphi^{(r)}.$$

In a similar manner we get

$$\frac{A^{(r+1)}}{\beta} - \frac{A^{(r+2)}}{\beta^2} + \frac{A^{(r+3)}}{\beta^3} -, \&c. = \varphi'^{(r)},$$
$$\frac{A^{(r+1)}}{\gamma} - \frac{A^{(r+2)}}{\gamma^2} + \frac{A^{(r+3)}}{\gamma^3} -, \&c. = \varphi''^{(r)}, \&c.$$

Therefore, by adding all these formulæ, and substituting for the sum of $\varphi^{(r)}$, $\varphi'^{(r)}$, &c. the value of it already found, we shall finally obtain

$$A^{(r+1)} S_{-1} - A^{(r+2)} S_{-2} + A^{(r+3)} S_{-3} -, \&c.$$
$$= (n-r) A^{(r)},$$

the symbols S_{-1}, S_{-2}, &c. being put for the sums of the negative powers of the roots according to the indices underwritten. This formula will enable us to compute the sums of the negative powers of the roots.

If, in the formula for the sums of the positive powers of the roots, we make r successively equal to 1, 2, 3, &c. we shall get

$$A^{(1)} = S_1,$$
$$-2A^{(2)} = -A^{(1)} S_1 + S_2,$$
$$3A^{(3)} = A^{(2)} S_1 - A^{(1)} S_2 + S_3,$$
$$-4A^{(4)} = -A^{(3)} S_1 + A^{(2)} S_2 - A^{(1)} S_3 + S_4, \&c.$$

and from this we learn that the quantities S_1, S_2, S_3, &c. may be found by means of this expression, viz.

$$\frac{A^{(1)} - 2A^{(2)} z + 3A^{(3)} z^2 \ldots \pm A^{(n)} z^{n-1}}{1 - A^{(1)} z + A^{(2)} z^2 \ldots \pm A^{(n)} z^n} = S_1$$
$$+ S_2 \cdot z + S_3 \cdot z^2 +, \&c.$$

for if we multiply the series on the right-hand side of the sign of equality, by the denominator of the fraction on the other side, and then equate the co-efficients of the product to the like co-efficients of the numerator, we shall obtain the very formulæ set down above. Hence the sums of the powers of the roots expressed in terms of the co-efficients of the polynome will be found by developing the fraction in a series. In effecting the development different analytical methods may be followed; and the quantities sought will thus be obtained by different rules, or exhibited in expressions of different forms, such as those given by Waring, Vandermonde, Euler, and La Grange.

And in like manner, if, in the formula for the sums of the negative powers of the roots, we make r successively equal to $n-1$, $n-2$, $n-3$, &c. we shall get

$$A^{(n-1)} = A^{(n)} S_{-1},$$
$$-2A^{(n-2)} = -A^{(n-1)} S_{-1} + A^{(n)} S_{-2},$$
$$3A^{(n-3)} = A^{(n-2)} S_{-1} - A^{(n-1)} S_{-2} + A^{(n)} S_{-3},$$
$$-4A^{(n-4)} = -A^{(n-3)} S_{-1} + A^{(n-2)} S_{-2}$$
$$- A^{(n-1)} S_{-3} + A^{(n)} S_{-4},$$
&c.

from which it appears that the values of all the quantities S_{-1}, S_{-2}, S_{-3}, &c. will be obtained by means of this expression, viz.

$$\frac{A^{(n-1)} - 2A^{(n-2)} z + 3A^{(n-3)} z^2 -, \&c.}{A^{(n)} - A^{(n-1)} z + A^{(n-2)} z^2 -, \&c.} = S_{-1}$$
$$+ S_{-2} \cdot z + S_{-3} \cdot z^2 +, \&c.$$

Two kinds of quantities only can enter into any rational and symmetrical function of the roots of an equation; and these are the sums of the like powers of the roots, and the sums of such products as, $\alpha^i \beta^{i'} \gamma^{i''}$, &c. which arise from multiplying different powers of the roots, two and two, three and three, &c. We shall now shortly point out in what manner the latter sums are deduced from the sums of the like powers, for the computation of which rules have already been given; by which means we shall be enabled to find the value of any proposed function of the kind above mentioned.

Let it be required to find the sum of all the products, such as $\alpha^i \beta^{i'}$, that arise from combining two powers of the roots in all possible ways; which sum may be denoted by the symbol $\Sigma \, . \, \alpha^i \beta^{i'}$. Now it is evident that the product, $S_i \times S_{i'}$, will contain two sorts of terms only, namely, powers of the roots, such as $\alpha^{i+i'}$, and the products of which the sum is sought; therefore

$$\Sigma \, . \, \alpha^i \beta^{i'} = S_i \times S_{i'} - S_{i+i'}.$$

Next let it be required to find $\Sigma \, . \, \alpha^i \beta^{i'} \gamma^{i''}$, or the sum of all the products of three powers of the root. Now $\Sigma \, . \, \alpha^i \beta^{i'} \times S_{i''}$ will contain three sorts of terms, namely, products, such as $\alpha^{i+i''} \beta^{i'}$ and $\alpha^{i'+i''} \beta^i$, in which two roots only are combined, and the products of which the sum is required; therefore

$$\Sigma \, . \, \alpha^i \beta^{i'} \gamma^{i''} = \Sigma \alpha^i \beta^{i'} \times S_{i''}$$
$$- \Sigma \, . \, \alpha^{i+i''} \beta^{i'}$$
$$- \Sigma \, . \, \alpha^{i'+i''} \beta^i :$$

but, according to the last case,

$$\Sigma \, . \, \alpha^{i+i''} \beta^{i'} = S_{i+i''} \times S_{i'} - S_{i+i'+i''},$$
$$\Sigma \, . \, \alpha^{i'+i''} \beta^i = S_{i'+i''} \times S_i - S_{i+i'+i''} :$$

wherefore

$$\Sigma \, . \, \alpha^i \beta^{i'} \gamma^{i''} = S_i \times S_{i'} \times S_{i''}$$
$$- S_{i+i'} \times S_{i''}$$
$$- S_{i+i''} \times S_{i'}$$
$$- S_{i'+i''} \times S_i$$
$$+ 2S_{i+i'+i''}.$$

In like manner, when four different powers of the roots are multiplied together, we get

$$\Sigma \, . \, \alpha^i \beta^{i'} \gamma^{i''} \delta^{i'''} = \Sigma \, . \, \alpha^{i} \beta^{i'} \gamma^{i''} \times S_{i'''}$$
$$- \Sigma \, . \, \alpha^{i+i'''} \beta^{i'} \gamma^{i''}$$
$$- \Sigma \, . \, \alpha^{i'+i'''} \beta^i \gamma^{i''}$$
$$- \Sigma \, . \, \alpha^{i''+i'''} \beta^{i'} \gamma^i ;$$

and we have only to apply the preceding case in order to obtain the expression of the quantity sought in terms of the sums of the like powers of the roots.

According to the procedure just explained, the case where any number of powers are multiplied together, is reduced to the simpler case where the powers multiplied are one less. There would be no great difficulty in de-

Equations. ducing a general formula for the sum when the products contain any proposed number of different powers; but this would lead to calculations incompatible with the length of this article; and it may be doubted whether the use of such a formula is preferable in any cases likely to occur in practice, to the application of the principles here laid down.

The theory of symmetrical functions is of the most extensive use in every branch of the doctrine of equations. Thus, if it be required to form an equation, the roots of which shall be any combinations of the roots of a given equation; it is manifest that the co-efficients of the equation sought will be symmetrical functions of the roots of the given equation; and hence they may be found by calculating these functions in terms of the co-efficients of the given equation.

The theory of symmetrical functions is also of use in approximating to the roots of numerical equations. Sir Isaac Newton seems to have had this application in view in giving his rule for computing the sums of the like powers of the roots. He observes that the powers of a great number increase in a much higher ratio than the same powers of less numbers; and hence the $2r^{\text{th}}$ power of the greatest root of an equation will approach nearer to the sum of the $2r^{\text{th}}$ powers of all the roots as r is greater. Wherefore, neglecting the distinction between positive and negative roots, if we calculate S_{2r}, and then extract its $2r^{\text{th}}$ root, we shall have an approximation to the root of the equation greatest in point of magnitude; and the approximation will be so much more accurate as r is greater.

But there is a more convenient way of approximating to the greatest and least roots of an equation, by means of symmetrical functions. For, since

$$S_{r+1} = \alpha^{r+1} + \beta^{r+1} +, \&c.$$

$$S_r = \alpha^r + \beta^r +, \&c.$$

we have

$$\frac{S_{r+1}}{S_r} = \alpha \cdot \frac{1 + \dfrac{\beta^{r+1}}{\alpha^{r+1}} +, \&c.}{1 + \dfrac{\beta^r}{\alpha^r} +, \&c.};$$

Now, α being the greatest root, the fraction on the right-hand side will approach to unit when r is sufficiently large, in which case $\dfrac{S_{r+1}}{S_r}$ will be nearly equal to α. Hence, if we compute a series of consecutive sums, viz. S_r, S_{r+1}, S_{r+2}, &c.; the values

$$\frac{S_{r+1}}{S_r}, \frac{S_{r+2}}{S_{r+1}}, \frac{S_{r+3}}{S_{r+2}}, \&c.$$

will approach nearer and nearer to the greatest root of the equation.

In like manner, if we take the sums of the negative powers of the roots, we shall have

$$\frac{S_{-r}}{S_{-r-1}} = \alpha \cdot \frac{1 + \dfrac{\alpha}{\beta^r} +, \&c.}{1 + \dfrac{\alpha^{r+1}}{\beta^{r+1}} +, \&c.};$$

from which it appears that $\dfrac{S_{-r}}{S_{-r-1}}$ will approximate so much more to α, the least root of the equation, as r is greater. Equations.

Trinomial Divisors.

10. We proceed next to consider the trinomial divisors of a given polynome; and, in order to avoid reference to other treatises, we shall begin with a short investigation of a preliminary point.

We have this identical expression,

$$x^2 - y^2 = (x+y) \cdot (x-y):$$

consequently,

$$(x^2 - y^2)^n = (x+y)^n \cdot (x-y)^n;$$

and again,

$$(x^2 - y^2)^n = \frac{1}{4} \cdot \left\{ (x+y)^n + (x-y)^n \right\}^2 - \frac{1}{4} \cdot \left\{ (x+y)^n - (x-y)^n \right\}^2$$

Now, using the letters H and G as the characteristics of the particular functions under consideration, let

$$H_n(x, y^2) = \frac{1}{2} \cdot \left\{ (x+y)^n + (x-y)^n \right\},$$

$$G_n(x, y^2) = \frac{1}{2} \cdot \frac{(x+y)^n - (x-y)^n}{y};$$

or by expanding the binomial quantities in series,

$$H_n(x, y^2) = x^n + n \cdot \frac{n-1}{2} \cdot x^{n-2} y^2 +, \&c.$$

$$G_n(x, y^2) = nx^{n-1} + n \cdot \frac{n-1}{2} \cdot \frac{n-2}{3} x^{n-3} y^2 +, \&c.;$$

then, by means of these notations, the preceding expression will be thus written, viz.

$$(x^2 - y^2)^n = \left\{ H_n(x, y^2) \right\}^2 - y^2 \cdot \left\{ G_n(x, y^2) \right\}^2.$$

This equation is identical; that is, when the expressions on both sides of the sign of equality are expanded in series of terms containing the powers of y^2, they will consist of the same quantities with the same signs. It is evident, therefore, that the equation will still be identical if we change y^2 into $-y^2$; for by this change the simple quantities of the developed expressions will not be affected, and no alteration will be produced, except in the signs of the odd powers of y^2, which will now be contrary to what they were before. We therefore have

$$(x^2 + y^2)^n = \left\{ H_n(x, -y^2) \right\}^2 + y^2 \cdot \left\{ G_n(x, -y^2) \right\}^2;$$

in which equation it is to be observed that the functional expressions are not, as in the former instance, susceptible of an abridged algebraic notation, at least without introducing a new sign; but they can be exhibited in series, viz.

$$H_n(x, -y^2) = x^n - n \cdot \frac{n-1}{2} \cdot x^{n-2} y^2 + n \cdot \frac{n-1 \cdot n-2 \cdot n-3}{2 \cdot 3 \cdot 4} x^{n-4} y^2 -, \&c.$$

$$G_n(x, -y^2) = nx^{n-1} - n \cdot \frac{n-1 \cdot n-2}{2 \cdot 3} x^{n-3} y^2 +, \&c.$$

Now put $x = r \cos. \varphi$, $y = r \sin. \varphi$, $x^2 + y^2 = r^2$; and let $\varphi^{(n)}$ denote an arc, depending, in a certain manner, not yet discovered, upon the arc φ and the index n; then, in consequence of the equation obtained above, we shall have

$$r^n \cos. \varphi^{(n)} = H_n(x, -y^2),$$

$$r^n \sin. \varphi^{(n)} = y G_n(x, -y^2).$$

Again, multiply both sides of the same equation last referred to by $x^2 + y^2$; then

$$(x^2+y^2)^{n+1}=\left\{x\,.\,\mathrm{H}_n(x,-y^2)-y^2\mathrm{G}_n(x,-y^2)\right\}^2$$
$$+y^2\left\{\mathrm{H}_n(x,-y^2)+x\mathrm{G}_n(x,-y^2)\right\}^2,$$

but, since the equation alluded to is general for all the values of n, we may write $n+1$ for n; and thus we get

$$(x^2+y^2)^{n+1}=\left\{\mathrm{H}_{n+1}(x,-y^2)\right\}^2$$
$$+y^2\left\{\mathrm{G}_{n+1}(x,-y^2)\right\}^2:$$

therefore, by comparing the two values of $(x^2+y^2)^{n+1}$

$$\mathrm{H}_{n+1}(x,-y^2)=x\,.\,\mathrm{H}_n(x,-y^2)-y^2\mathrm{G}(x,-y^2),$$
$$y\mathrm{G}_{n+1}(x,-y^2)=y\mathrm{H}_n(x,-y^2)+yx\mathrm{G}n(x,-y^2):$$

and finally, by substituting the values of the functions in terms of the arcs, φ, $\varphi^{(n)}$, $\varphi^{(n+1)}$, we shall obtain

$$\cos.\varphi^{(n+1)}=\cos.\varphi\cos.\varphi^{(n)}-\sin.\varphi\sin.\varphi^{(n)}=\cos.(\varphi^{(n)}+\varphi),$$
$$\sin.\varphi^{(n+1)}=\cos.\varphi\sin.\varphi^{(n)}+\sin.\varphi\cos.\varphi^{(n)}=\sin.(\varphi^{(n)}+\varphi),$$
$$\varphi^{(n+1)}=\varphi^{(n)}+\varphi.$$

Now, if we make n successively equal to 1, 2, 3, &c. the results will be,

$$\varphi^{(2)}=2\varphi,$$
$$\varphi^{(3)}=3\varphi,$$
&c.

and generally, $\varphi^{(n)}=n\varphi$.

Thus it appears that

$$r^n\cos.n\varphi=\mathrm{H}_n(x,-y^2),$$
$$r^{n-1}\times\frac{\sin.n\varphi}{\sin.\varphi}=\mathrm{G}_n(x,-y^2);$$

or, if we take the expanded expressions of the functions,

$$r^n\cos.n\varphi=x^n-n.\frac{n-1}{2}x^{n-2}y^2+$$
$$n.\frac{n-1\,.\,n-2\,.\,n-3}{2\,.\,3\,.\,4}x^{n-4}y^2-,\ \&c.$$
$$r^{n-1}\times\frac{\sin.n\varphi}{\sin.\varphi}=nx^{n-1}-n.\frac{n-1\,.\,n-2}{2\,.\,3}x^{n-3}y^2+,\ \&c.$$

in which formulæ, $x=r\cos.\varphi$, $y=r\sin.\varphi$.

The functions here designated by the letters H and G may be expressed by means of the imaginary sign; for we have

$$\mathrm{H}_n(x,-y^2)=\frac{(x+y\sqrt{-1})^n+(x-y\sqrt{-1})^n}{2},$$
$$\mathrm{G}_n(x,-y^2)=\frac{(x+y\sqrt{-1})^n-(x-y\sqrt{-1})^n}{2y\sqrt{-1}};$$

And, in the case of $r=1$, the formulæ obtained above are equivalent to the expressions known in analysis since the time of Dr Moivre, viz.

$$\cos.n\varphi=\frac{(\cos.\varphi+\sin.\varphi\sqrt{-1})^n+(\cos.\varphi-\sin.\varphi\sqrt{-1})^n}{2}$$
$$\sin.n\varphi=\frac{(\cos.\varphi+\sin.\varphi\sqrt{-1})^n-(\cos.\varphi-\sin.\varphi\sqrt{-1})^n}{2\sqrt{-1}}.$$

But the mode of investigation we have followed is rigorous; and it has the advantage of leading to the true import of the imaginary sign, and of putting in a clear light its real effect in analytical operations. The real use of this sign may be shortly described by saying that it performs for even and odd functions the same office that the negative sign does for ordinary functions; in other words, when, by means of the ordinary operations of analysis, it has been proved that an even or odd function of an indeterminate quantity is equal to zero, it is by means of the impossible sign that the same equation is extended to the case when the square of the indeterminate quantity is negative. Every function of the indeterminate quantity x may be thus represented, viz.

$$\varphi(x^2)\pm x\Psi(x^2);$$

and the substitution of $x\sqrt{-1}$ in place of x, has no other effect than to change the preceding expression into the one following, viz.

$$\varphi(-x^2)\pm x\sqrt{-1}\,.\,\Psi(-x^2);$$

and from this it is obvious, that the same operations which, in the one case, lead us to the equations $\varphi(x^2)=0$ and $x\Psi(x^2)=0$, will, in the other, necessarily conduct us to the equations $\varphi(-x^2)=0$ and $x\,.\,\Psi(-x^2)=0$. It is to be observed, too, that the truth of the two latter equations is involved in that of the former. For the former equations cannot be generally true for all values of x^2, unless they are identical, or consist of equal quantities with opposite signs that mutually destroy one another; in which case the latter equations will also be identical. The sign of impossibility, as it has been called, is therefore one as truly significant as any other in analysis. It has, indeed, no consistent meaning when we consider it as only affecting x, or the indeterminate quantity to which it is joined; but it becomes perfectly intelligible when we contemplate the real changes produced by it in the functions of even and odd dimensions, in which its conclusions are always ultimately expressed. When the true import and real effect of the imaginary sign are clearly apprehended, the truth of its conclusion is no longer doubtful or mysterious, but follows as a necessary consequence of a fundamental principle of analytical language. Proceeding on this principle, we may even lay aside the imaginary character; and, in every particular case, with the assistance of a proper notation, arrive, by the ordinary operations, at the same conclusion to which it leads, as has been done in the preceding instance. It is to be observed further, that the imaginary arithmetic is not merely a short method of calculation convenient in practice, and that it may be dispensed with; it is strictly a necessary branch of analysis, without which, or some equivalent mode of investigation, that science would be extremely imperfect. The equations $\varphi(x^2)=0$ and $x\Psi(x^2)=0$, are unchangeable by any operations with the signs commonly received, by the use of which alone it is impossible to deduce, in a direct manner, the related equations $\varphi(-x^2)=0$ and $x\Psi(-x^2)=0$: although the latter are equally true, of as frequent occurrence, and as extensive application, as the former. Without the impossible sign the operations of algebra would, therefore, be defective; since there are analytical truths that could not be investigated in a direct manner by means of the elementary signs usually admitted. It is to supply this defect that the imaginary arithmetic has been introduced, and has grown up to be an extensive branch of analysis; advancing at first by slow steps, because the true import of the character it employs, and the real effect of its operations, were neither clearly perceived nor fully understood. But having premised what is conducive to our present purpose, we proceed to the investigation of the trinomial divisors of rational functions.

11. Every polynome of odd dimensions having at least one binomial factor, it may, by dividing by that factor, be reduced to another polynome one degree lower. And hence, in this part of our subject, we may confine our attention to polynomes of even dimensions. We may also suppose that the even polynomes under consideration have no double, triple, &c. factors of any kind: since, in case

any such are present, they can be found separately and eliminated by division.

Suppose, then, that $f(x)$ represents any polynome of even dimensions; let $\varrho + u$ be substituted in place of x; and, by using the notation of the differential calculus, the given polynome will be transformed into

$$f(\varrho) + \frac{df(\varrho)}{d\varrho} \cdot u + \frac{1}{2} \cdot \frac{d^2f(\varrho)}{d\varrho^2} \cdot u^2 +, \&c.$$

Since $f(x)$ is an even polynome, the equation $\frac{df(x)}{dx} = 0$ will be one of odd dimensions, having at least one root. Let ϱ be the sole root of $\frac{df(x)}{dx} = 0$, when it has but one, and the greatest root when it has several; then, because $\frac{df(\varrho)}{d\varrho} = 0$, the transformed function will become

$$f(\varrho) + \frac{1}{2} \cdot \frac{d^2f(\varrho)}{d\varrho^2} u^2 + \frac{1}{6} \cdot \frac{d^3f(\varrho)}{d\varrho^3} \cdot u^3 +, \&c.$$

It readily appears, from what was formerly proved (Sect. 8), that ϱ, the greatest root of $\frac{df(x)}{dx} = 0$, exceeds the greatest root of any of the equations, $\frac{1}{2} \cdot \frac{d^2f(x)}{dx^2} = 0$, $\frac{1}{6} \cdot \frac{d^3f(x)}{dx^3} = 0$, &c.; and because, in any equation, the substitution of a value greater than the greatest root must give a positive result, all the quantities $\frac{1}{2} \cdot \frac{d^2f(\varrho)}{d\varrho^2}$, $\frac{1}{6} \cdot \frac{d^3f(\varrho)}{d\varrho^3}$, &c. will be positive. With regard to $f(\varrho)$ it may be either positive or negative, but not equal to zero; since this last case can happen only when the polynome has equal roots. The original polynome will, therefore, assume this form, viz.

$$\mp y + A^{(2)}u^2 + A^{(3)}u^3 + A^{(4)}u^4 \ldots + A^{(2n-1)}u^{2n-1}$$

$+ u^{2n}$, in which expression y, $A^{(2)}$, $A^{(3)}$, &c. represent any positive quantities.

The most interesting proposition in the branch of the subject under consideration, is to prove that every polynome of even dimensions has a quadratic divisor, either of the form $(u + \alpha)^2 - r^2$, which admits two real binomial factors, or of the form $(u - \alpha)^2 + r^2$, which has two imaginary factors. By the preceding transformation this proposition is brought under two cases, according as y is affected with the sign *minus* or *plus*; the quadratic divisor being always of the form $(u + \alpha)^2 - r^2$ in the first case, and always of the form $(u - \alpha)^2 + r^2$ in the other case; a distinction that agrees with what was before proved, Sect. 8.

Now the first of these cases is attended with no difficulty. For two values of u, one negative and one positive, may be found that will satisfy the equation, Sect. 4.

$$y = A^{(2)}u^2 + A^{(3)}u^3 + A^{(4)}u^4 \ldots + u^{2n}.$$

Of these values, it is obvious that the negative one will be always greater than the positive one; and they may, therefore, be represented by $-(r + \alpha)$ and $r - \alpha$: wherefore, the polynome

$$-y + Au^2 + A^{(3)}u^3 + A^{(4)}u^4 \ldots\ldots + u^{2n},$$

will be divisible by each of the binomial factors,

$$u + r + \alpha,$$
$$u - r + \alpha;$$

and likewise by the quadratic factor,

$$(u + \alpha)^2 - r^2,$$

produced by their multiplication.

But the same mode of reasoning will not apply when y has the sign *plus*; in which case the demonstration must be deduced from other principles.

12. If we put

$$\varphi(u) = A^{(2)}u^2 + A^{(3)}u^3 + A^{(4)}u^4 \ldots + u^{2n},$$

the transformed polynome, supposing y to have the sign *plus*, will become

$$y + \varphi(u).$$

Let $(u - \alpha)^2 + r^2$ be a quadratic divisor of this polynome, and put $u - \alpha = z$, or $u = \alpha + z$; then, by substituting $\alpha + z$ for u, and writing all the terms of the transformed function $\varphi(\alpha + z)$ in two lines, one containing all the even and the other all the odd powers of z, the polynome $y + \varphi(u)$ will be equal to

$$y + \varphi(\alpha) + \frac{1}{2} \cdot \frac{d^2\varphi(\alpha)}{d\alpha^2} \cdot z^2 + \frac{1}{24} \cdot \frac{d^4\varphi(\alpha)}{d\alpha^4} z^4 +, \&c.$$
$$+ z \cdot \left\{ \frac{d\varphi(\alpha)}{d\alpha} + \frac{1}{6} \cdot \frac{d^3\varphi(\alpha)}{d\alpha^3} \cdot z^2 +, \&c. \right\}.$$

By the same substitution of z for $u - \alpha$, the divisor $(u - \alpha)^2 + r^2$ is changed into the binomial quantity $z^2 + r^2$; which will be a divisor of each of the preceding lines, if $-r^2$, when it is substituted for z^2, render each of them equal to zero, Sect. 3. Hence we obtain the two following equations, viz.

$$0 = y + \varphi(\alpha) - \frac{1}{2} \cdot \frac{d^2\varphi(\alpha)}{d\alpha^2} r^2 + \frac{1}{24} \cdot \frac{d^4\varphi(\alpha)}{d\alpha^4} r^4 -, \&c.$$
$$0 = \frac{d\varphi(\alpha)}{d\alpha} - \frac{1}{6} \cdot \frac{d^3\varphi(\alpha)}{d\alpha^3} r^2 +, \&c. \qquad \text{(C)}$$

If two numbers, α and r^2, can be found that will satisfy these equations, it is evident that $z^2 + r^2$ will be a divisor of each of the two lines that compose the transformed function $y + \varphi(\alpha + z)$; consequently it will be a divisor of the sum of both lines, or of the function itself, that is, $(u - \alpha)^2 + r^2$ will be a divisor of the proposed polynome $y + \varphi(u)$. We are now to prove that two such numbers may be found.

Substitute $\lambda^2\alpha^2 - s$ for r^2 in the equations (C), λ being a quantity to be afterwards determined; and, in order to shorten expressions, put

$$M = \varphi(\alpha) - \frac{1}{2} \cdot \frac{d^2\varphi(\alpha)}{d\alpha^2} (\lambda^2\alpha^2 - s) + \frac{1}{24} \cdot \frac{d^4\varphi(\alpha)}{a\alpha^4} \times$$
$$(\lambda^2\alpha^2 - s)^2 - \&c.$$
$$N = \frac{d\varphi(\alpha)}{d\alpha} - \frac{1}{6} \cdot \frac{d^3\varphi(\alpha)}{d\alpha^3} (\lambda^2\alpha^2 - s) +, \&c.$$

And the two equations (C) will be thus written, viz.

$$y + M = 0,$$
$$N = 0.$$

In these equations α and s are always supposed to represent positive numbers, in which case the equation $N = 0$ cannot take place when s is greater than $\lambda^2\alpha^2$; for then all the terms of N would be positive.

Considering N as a function of α, the part of it that does not contain α is evidently

$$A^{(3)}s + A^{(5)}s^2 + A^{(7)}s^3 +, \&c.$$

which is always positive. The highest power of α contained in the same function is α^{2n-1}; and we shall obtain all the terms of N that contain this power by putting α^{2n} for $\varphi(\alpha)$ in the expression

$$\frac{d\varphi(\alpha)}{d\alpha} - \frac{1}{6} \cdot \frac{d^3\varphi(\alpha)}{d\alpha^3}\lambda^2\alpha^2 + \frac{1}{120} \cdot \frac{d^5\varphi(\alpha)}{d\alpha^5}\lambda^4\alpha^4 -, \&c.;$$

which terms are therefore as follows, viz.

$$\alpha^{2n-1} \left\{ 2n - 2n.\frac{2n-1 \,.\, 2n-2}{2 \;.\; 3} \lambda^2 + \right.$$

Equations.

$$2n.\frac{2n-1\,.\,2n-2\,.\,2n-3\,.\,2n-4}{2\quad.\quad3\quad.\quad4\quad.\quad5}\lambda^4+,\&c.\Big\}.$$

Now, in the expression obtained in Sect. 10, viz.

$$r^{2n-1}\times\frac{\sin.2n\varphi}{\sin.\varphi}=2nx^{2n-1}-2n.\frac{2n-1\,.\,2n-2}{2\quad.\quad3}x^{2n-3}y^2+,\&c.$$

if we put $\lambda^2=\frac{y^2}{x^2}=\tan.^2\varphi$, and divide both sides by $x^{2n-1}=r^{2n-1}\cos.^{2n-1}\varphi$; we shall obtain

$$\frac{\sin.2n\varphi}{\sin.\varphi}\times\frac{1}{\cos.^{2n-1}\varphi}=2n-2n\cdot\frac{2n-1\,.\,2n-2}{2\quad.\quad3}\lambda^2+,\&c.;$$

from which formula it follows, that the polynome on the right-hand side of the sign of equality will be equal to nothing, where $\varphi=\pm\frac{m}{n}\times90°$, m being any integer number less than n, zero not included. Wherefore the first, third, &c. roots of the polynome will be expressed by the formula

$$\lambda^2=\tan.^2\frac{2k+1}{n}\cdot90,$$

$2k+1$ representing any odd number less than n; and the second, fourth, &c. roots by the formula

$$\lambda^2=\tan.^2\frac{2k+2}{n}\cdot90°,$$

$2k+2$ being any even number less than n. And it is evident that the polynome will be negative for every value of λ^2 that lies between any odd root and the next even root, that is, for every value between these limits, viz.

$$\lambda^2>\tan.^2\frac{2k+1}{n}\cdot90°,$$

$$\lambda^2<\tan.^2\frac{2k+2}{n}\cdot90°.$$

Thus, an indefinite number of values of λ^2 may be found that will make the polynome negative.

Having assumed such a value of λ^2, let any positive number whatever be substituted for s, and N will be converted into a rational function of α; the greatest power of α, or α^{2n-1}, being odd, and having a negative co-efficient; and the term which does not contain α being positive. Wherefore at least one positive value of α may be found that will satisfy the equation $N=0$; and, as has already been observed, this value of α will be such as to make $\lambda^2\alpha^2-s$ a positive quantity. It is possible indeed that, in the equation $N=0$, there may be several values of α for every assumed value of s; but we here confine our attention to the least positive value, which is distinguished by this circumstance, that it vanishes with the absolute term of the equation, or with s; whereas, when s is equal to zero, all the other roots of the equation $N=0$ have finite values depending upon the given co-efficients.

Now, if we suppose s to increase from zero to infinity, and assume two values, s, and $s+\delta s$, very near one another, according to what has been proved, we shall have the corresponding values α and $\alpha+\delta\alpha$, such, that the equation $N=0$ will be satisfied by substituting both s and α, and likewise $s+\delta s$ and $\alpha+\delta\alpha$. Hence, because $N=0$, and $\delta N=0$, we get

$$\frac{dN}{d\alpha}.\delta\alpha+\frac{dN}{ds}.\delta s=0,$$

$$\text{and, }\delta\alpha=-\frac{\delta s}{\left(\frac{dN}{d\alpha}\right)}\times\frac{dN}{ds}.$$

Again, if we substitute first s and α, and then $s+\delta s$ and $\alpha+\delta\alpha$, in the function M, we shall get

Equations.

$$\delta M=\frac{dM}{d\alpha}.\delta\alpha+\frac{dM}{ds}.\delta s.$$

But, by comparing the functions M and N, the following properties will readily be discovered, viz.

$$\frac{dM}{d\alpha}+2\lambda^2\alpha.\frac{dM}{ds}=N-2\frac{dN}{ds}(\lambda^2\alpha^2-s),$$

$$\frac{dM}{ds}=\frac{1}{2}\cdot\frac{dN}{d\alpha}+\lambda^2\alpha\cdot\frac{dN}{ds}:$$

whence,

$$\frac{dM}{d\alpha}=N-2\frac{dN}{ds}(\lambda^2\alpha^2-s)-\frac{dN}{d\alpha}\lambda^2\alpha-2\lambda^4\alpha^2\frac{dN}{ds}.$$

Consequently,

$$\delta M=\left\{N-2\frac{dN}{ds}(\lambda^2\alpha^2-s)-\frac{dN}{d\alpha}\lambda^2\alpha-2\lambda^4\alpha^2\cdot\frac{dN}{ds}\right\}\times\delta\alpha+\left\{\frac{1}{2}\cdot\frac{dN}{d\alpha}+\lambda^2\alpha\cdot\frac{dN}{ds}\right\}\cdot\delta s:$$

and, if we observe that $N=0$, and substitute the value of $\delta\alpha$ found above, we shall get

$$\delta M=\frac{-\delta s}{\left(\frac{dN}{d\alpha}\right)}.-\left\{2\left(\frac{dN}{ds}\right)^2(\lambda^2\alpha^2-s)+\frac{1}{2}\left(\frac{dN}{d\alpha}+2\lambda^2\alpha\frac{dN}{ds}\right)^2\right\},$$

in which expression all the quantities are essentially positive, except $\frac{dN}{d\alpha}$, which is always negative, as may be thus proved.

The quantity s remaining invariable, if we make $\alpha=0$, the function N will be positive; for it is equal to

$$A^{(3)}s+A^{(5)}s^2+A^{(7)}s^3+,\&c.;$$

and the same function will continue positive, while α increases from zero to the least root of the equation $N=0$. At this limit N is first equal to zero, and then becomes negative; it must, therefore, be decreasing, and consequently $\frac{dN}{d\alpha}$ is negative. It mav indeed happen, that, for particular values of s, the co-efficients of N may be such, that N and $\frac{dN}{d\alpha}$ shall be both equal to zero at the same time; but, in such cases, it will readily appear that $\frac{dN}{ds}$ and δM will likewise be equal to zero. Wherefore δM will be negative; at least, if it become equal to zero for any particular values of s and α, it cannot become positive. It follows, therefore, that the function M itself will be invariably negative, while s and α increase together from zero to be infinitely great.

Now assume a series of values of s increasing from zero without limit, viz.

$$0,s^{(1)},s^{(2)},s^{(3)},\ldots\ldots s^{(x)},s^{(x+1)}\ldots.$$

and having substituted these in the function N, find, by means of the equation $N=0$, the corresponding values of α, viz.

$$0,\alpha^{(1)},\alpha^{(2)},\alpha^{(3)},\ldots\ldots\alpha^{(x)},\alpha^{(x+1)}\ldots$$

then, by substituting these values in M, we shall obtain a series of results all negative, and increasing from zero without limit, viz.

$$0,-M^{(1)},-M^{(2)},-M^{(3)}..-M^{(x)},-M^{(x+1)}..$$

 and whatever be the magnitude of the positive quantity y, it must be contained between two consecutive terms of this last series, viz. between $M^{(x)}$ and $M^{(x+1)}$. But as the values of s may be assumed as near one another as we please, it follows that $M^{(x)}$ and $M^{(x+1)}$ may be made to approach to one another and to y, within any required degree of accuracy. Thus two values of s and α may be found that will satisfy both the equations,

$$y + M = 0,$$
$$N = 0;$$

and having found these values, we shall obtain the quadratic divisor of the proposed polynome $y + \varphi(u)$, viz. $(u-\alpha)^2 + r^2$, or

$$(u-\alpha)^2 + \lambda^2\alpha^2 - s.$$

In the preceding demonstration it is supposed that M increases without limit, as s becomes indefinitely great; which may be thus proved: The values of M and N will coincide nearly with the terms containing the highest powers of s and α, when these quantities are very great; and ultimately the functions may be considered as equal to those terms alone. In such circumstances, therefore, the values of the functions will be found by writing α^{2n} for $\varphi(\alpha)$; whence we get

$$M = \alpha^{2n} - 2n.\frac{2n-1}{2}.\alpha^{2n-2}(\lambda^2\alpha^2 - s) +, \&c.$$

$$N = 2n\,\alpha^{2n-1} - 2n.\frac{2n-1\cdot 2n-2}{2\ .\ 3}(\lambda^2\alpha^2 - s) +, \&c.$$

and if we put $\lambda^2\alpha^2 - s = t^2\alpha^2$, or $\alpha^2 = \frac{s}{\lambda^2 - t^2}$,

then $M = \alpha^{2n}\left\{1 - 2n.\frac{2n-1}{2}.t^2 +, \&c.\right\}$

$$N = \alpha^{2n-1}\left\{2n - 2n.\frac{2n-1\cdot 2n-2}{2\ \cdot\ 3}.t^2 +, \&c.\right\}$$

Now, s remaining invariable, α will increase as t^2 increases; and the least value of α that will satisfy the equation $N = 0$, corresponds to the least value of t^2 that will make the polynome in the expression of N equal to zero; which value, according to what was before shown, is

$$t^2 = \tan.^2 \frac{1}{n} \times 90°.$$

But, if we put $t = \tan.\ \varphi$, we shall get

$$M = \alpha^{2n} \times \frac{\cos.\ 2n\varphi}{\cos.^{2n}\varphi};$$

or, because $\varphi = \frac{1}{n} \times 90°$; $\cos.\ \varphi = \frac{1}{\sqrt{1+t^2}}$,

and $\alpha^2 = \frac{s}{\lambda^2 - t^2}$;

$$M = -s^n \times \left(\frac{1+t^2}{\lambda^2 - t^2}\right)^n;$$

which proves the point assumed in the demonstration.

By a similar mode of reasoning, we may likewise prove the former case of the proposition, when y is negative. In this case the quadratic divisor is $(u-\alpha)^2 - r^2$; and if we proceed as before, or, which is the same thing, if we change the signs of y and r^2 in the equations (C) already obtained, and put

$$M = \varphi(\alpha) + \frac{1}{2}\cdot\frac{d^2\varphi(\alpha)}{d\alpha^2}\cdot r^2 +, \&c.$$

$$N = \frac{d\varphi(\alpha)}{d\alpha} + \frac{1}{6}\cdot\frac{d^3\varphi(\alpha)}{d\alpha^3}r^2 +, \&c.;$$

we shall get

$$-y + M = 0,$$
$$N = 0.$$

Now, by pursuing the steps of the foregoing analysis, we may prove, first, that, for every assumed value of r^2, a negative value of α may be found, which will satisfy the equation $N = 0$; and, secondly, that when the values which satisfy the equation $N = 0$ are substituted in the function M, the results will be invariably positive; whence it follows that a positive value of r^2, and a negative value of α, may be found that will satisfy both the equations, whatever be the magnitude of y. The analogy between the two cases is thus placed in a strong light; and a little reflection will even bring us to this conclusion, that in reality the one case is a necessary consequence of the other. For since α and r^2 depend only upon y, and the given co-efficients of the polynome, they will be functions of y; wherefore, in the equations of the first case, viz.

$$-y + M = 0,$$
$$N = 0,$$

α being negative, and r^2 positive, we may suppose $-\alpha = y\varphi(y)$ and $r^2 = y\Psi(y)$, these values being such as to render each of the equations identical; and then the quadratic divisor $(u-\alpha)^2 - r^2$ will become

$$\left\{u + y\,\varphi(y)\right\}^2 - y\Psi(y).$$

But, because the foregoing equations become identical by the substitution of the values mentioned, it is a necessary consequence that the equations of the second case, viz.

$$y + M = 0,$$
$$N = 0,$$

in which the signs of y, α, and r^2, are contrary to what they were in the former equations, will likewise be identical, when $-\alpha = -y\varphi(-y)$ and $r^2 = -y\Psi(-y)$; and the quadratic divisor, $(u-\alpha)^2 - r^2$, will now become

$$\left\{u - y\varphi(-y)\right\}^2 + y\Psi(-y).$$

Thus, when the quadratic divisor of the first case is expressed in terms of y, we have only to change the sign of that quantity, in order to have the quadratic divisor of the second case. It is not difficult to perceive, that what has now been proved is nothing more than another application of the principle employed in Sect. 10; a principle which is the real foundation of the imaginary arithmetic, with the processes of which the preceding investigations are intimately connected. None but real quantities have occurred in the analysis we have pursued, because we have sought to investigate r^2, which is always rational; whereas, if we had proposed to find r, we should inevitably have been led to the real quantity $\sqrt{y}$ in the one case, and to the impossible quantity $\sqrt{-y}$ in the other. These few observations are made for the purpose of throwing light upon a part of analysis which is certainly obscure in its principles, although there is no question that it is a useful, and even a necessary branch of the art of calculation. A fuller elucidation of the subject would be unsuitable to this place; but enough has been said to show that we must seek in the principles of analysis itself for the explanation of the operations it employs; and we may with great probability conclude that no satisfactory account of the imaginary calculus will ever be obtained by having recourse to fanciful geometrical constructions, or to the analogy between the circle and the hyperbola, or to the metaphysical proposition, that all processes with general symbols, whether signifi-

cant or not, are equally entitled to be considered as demonstrative.

13. Having now proved, in a rigorous manner, that every polynome of even dimensions has at least one quadratic divisor of the one kind or the other, it follows that it may be reduced by division to another polynome two degrees lower: in like manner, this last polynome will admit of being lowered two degrees more; and by repeating the same process, the first polynome will at length be completely exhausted by quadratic divisors. If, therefore, we recollect, that every polynome of odd dimensions has one binomial divisor, we shall arrive at this general conclusion, "That every rational polynome can be completely exhausted by binomial and trinomial divisors; and, consequently, that it is equal to the product of a certain number of factors of the two first degrees."

It appears also that the binomial factors of any polynome are such only as arise from the resolution of the quadratic divisors; and they are, therefore, either real or imaginary. And thus we finally obtain the following proposition, which was assumed by Harriot, and is the foundation of the received theory of equations, namely, "Every rational polynome has as many binominal factors, and as many roots, real and imaginary, as it has dimensions."

The necessity of confirming, by a general demonstration, the assumed theory of the impossible roots of equations, was early felt; and accordingly, this point has engaged the attention of all the great mathematicians to whom analysis is indebted for the progress it has made in the course of the last and the present centuries. An account of their several researches would greatly exceed the limits of this article; but the reader will find all the information he can wish for in two long notes (9 and 10) of the *Traité des Equations Numeriques*, by La Grange, in which the author, with his usual elegance, has explained and commented upon the various modes of investigation that have been proposed. It will be sufficient to observe here, that all the demonstrations that have appeared are either calculations with impossible quantities, or they proceed upon the assumption that every equation has as many roots as dimensions, and thus involve the very thing to be proved.

14. The general cases in which mathematicians have been successful in resolving rational functions into their trinomial factors, are confined to the theorem of Cotes, and to a more general proposition of a similar kind, for which we are indebted to De Moivre. These instances are of great importance in analysis, and we shall therefore subjoin an investigation of them, because they are deduced in a very direct manner from the method we have followed.

Suppose, as before, that $f(x)$, or $x^n + A^{(1)}x^{n-1} + A^{(2)}x^{n-2} \ldots + A^{(n-1)}x + A^{(n)}$, is a rational polynome of n dimensions, and $(x-\alpha)^2 + \tau^2$ one of its quadratic divisors; put $z = x - \alpha$, substitute $\alpha + z$ for x, and write the transformed function in two lines, one containing all the even, and the other all the odd powers of z; then the polynome will be equal to

$$f(\alpha) + \frac{1}{2}\cdot\frac{d^2f(\alpha)}{d\alpha^2}z^2 + \frac{1}{24}\cdot\frac{d^4f(\alpha)}{d\alpha^4}z^4 -, \text{ \&c.}$$

$$+ z \times \left\{\frac{df(\alpha)}{d\alpha} + \frac{1}{6}\ \frac{d^3f(\alpha)}{d\alpha^3}z^2 + \frac{1}{120}\cdot\frac{d^5f(\alpha)}{d\alpha^5}z^4, \text{ \&c.}\right\}$$

By the same substitution of z for $x - \alpha$, the divisor $(x-\alpha)^2 + \tau^2$ will become $z^2 + \tau^2$; and, as before, the conditions that $z^2 + \tau^2$ shall divide each of the foregoing lines, will be expressed by the following equations, viz.

$$0 = f(\alpha) - \frac{1}{2}\cdot\frac{d^2f(\alpha)}{d\alpha^2}\tau^2 + \frac{1}{24}\cdot\frac{d^4f(\alpha)}{d\alpha^4}\tau^4 -, \text{ \&c.} \quad \text{(D)}$$

$$0 = \frac{df(\alpha)}{d\alpha} - \frac{1}{6}\cdot\frac{d^3f(\alpha)}{d\alpha^3}\tau^2 + \frac{1}{120}\cdot\frac{d^5f(\alpha)}{d\alpha^5}\tau^4 -, \text{ \&c.}$$

In these formulæ substitute the expanded values of $f(\alpha)$, $\frac{df(\alpha)}{d\alpha}$, &c.; and class together all the homogeneous terms of the same order, that is, all the terms in which the exponents of α and τ amount to the same sum, then we shall have

$$0 = \alpha_n - n.\frac{n-1}{2}\alpha^{n-2}\tau^2 +, \text{ \&c.}$$

$$+ A^{(1)}.\left\{\alpha^{n-1} - n-1.\frac{n-2}{2}.\alpha^{n-3}\tau^2 +, \text{ \&c.}\right\}$$

$$+ A^{(2)}.\left\{\alpha^{n-2} - n-2.\frac{n-3}{2}\alpha^{n-4}\tau^2 +, \text{ \&c.}\right\}$$

&c.

$$0 = n\alpha^{n-1} - n.\frac{n-1.n-2}{2\ .\ 3}\alpha^{n-3}\tau^2 +, \text{ \&c.}$$

$$+ A^{(1)}.\left\{(n-1)\alpha^{n-2} - n-1.\frac{n-2.n-3}{2\ .\ 3}\alpha^{n-4}\tau^2 +, \text{ \&c.}\right\}$$

$$+ A^{(2)}.\left\{(n-2)\alpha^{n-3} - n-2.\frac{n-3.n-4}{2\ .\ 3}\alpha^{n-5}\tau^2 +, \text{ \&c.}\right\}$$

&c.

Now, put $\alpha = r\cos.\varphi$, $\tau = r\sin.\varphi$; and, by what was proved in Sect. 10, the two foregoing equations will become

$$r^n\cos.n\varphi + A^{(1)}r^{n-1}\cos.(n-1)\varphi \ldots\ldots + A^{(n-1)}r\cos.\varphi + A^{(n)} = 0, \quad \text{(E)}$$

$$\frac{1}{\sin.\varphi}.\left\{r^{n-1}\sin.n\varphi + A^{(1)}r^{n-2}\sin.(n-1)\varphi \ldots\ldots + A^{(n-)}\sin.\varphi\right\} = 0:$$

And the quadratic divisor $(x-\alpha)^2 + \tau^2$ will be changed into

$$x^2 - 2r\cos.\varphi.x + r^2.$$

When $\sin.\varphi = 0$, and $\varphi = 0$ or 180°, the preceding equations coincide with these, viz.

$$r^n \pm A^{(1)}r^{n-1} + A^{(2)}r^{n-2} \pm, \text{ \&c.} = 0,$$

$$nr^{n-1} \pm (n-1)A^{(1)}r^{n-2} + (n-2)A^{(2)}r^{n-3} \pm, \text{ \&c.} = 0,$$

which express the condition that the given polynome has two or more factors equal to $x \mp r$; at which limits a quadratic divisor changes from being of the form $(x-\alpha)^2 - \tau^2$ to be of the form $(x-\alpha)^2 + \tau^2$, or the contrary. Thus we learn that, in the equations (E), $\sin.\varphi$ must always have a finite value, and then the denominator of the second equation may be neglected.

Let the preceding investigation be applied to find the quadratic factors of $x^n - \alpha^n$. In this case the two equations (E) will become

$$r^n\cos.n\varphi - \alpha^n = 0,$$

$$r^{n-1} \times \frac{\sin. n\varphi}{\sin. \varphi} = 0;$$

whence

$$r = a,$$
$$\cos. n\varphi = 1,$$
$$\frac{\sin. n\varphi}{\sin. \varphi} = 0.$$

Now, excluding the cases when $\varphi = 0$ and $\varphi = 180°$, the last equation will be satisfied when $\varphi = \frac{2k+1}{n} \times 180°$, or $\varphi = \frac{2k}{n} \times 180°$, the numerators of the fractions representing all the odd and even numbers less than the common denominator; but the second equation will be satisfied only when $\varphi = \frac{2k}{n} \times 180°$; wherefore all the quadratic factors of the function $x^n - a^n$ will be comprehended in the formula

$$x^2 - 2ax \times \cos. \frac{2k}{n} \times 180° + a^2.$$

When n is an even number, the quadratic factors will amount to $\frac{n-2}{2}$; and if to them we add the simple factors $x + a$ and $x - a$, we shall have the complete resolution of the function. When n is odd, the number of quadratic factors is $\frac{n-1}{2}$, to which must be added the binomial factor $x - a$.

By proceeding in a similar manner in the case of the function $x^n + a^n$, we shall have the equations

$$r = a,$$
$$\cos. n\varphi = -1,$$
$$\frac{\sin. n\varphi}{\sin. \varphi} = 0.$$

Excluding the cases when $\varphi = 0$ and $\varphi = 180°$, the second and third equations will be both satisfied, when $\varphi = \frac{2k+1}{n} \times 180°$, the numerator of the fraction representing any odd number less than n. Wherefore all the quadratic factors will be comprehended in the formula

$$x^2 - 2ax \times \cos. \frac{2k+1}{n} \times 180° + a^2.$$

When n is even, the number of quadratic factors is $\frac{n}{2}$, and they exhibit the complete resolution of the function. When n is odd, the number of quadratic factors is $\frac{n-1}{2}$, to which the binomial factor $x + a$ must be added.

Let us next take the more general function.

$$x^{2n} - 2\beta x^n a^n + a^{2n}.$$

And, in the first place, when β is greater than unit, the function is equal to

$$\left\{x^n - a^n(\beta + \sqrt{\beta^2 - 1})\right\} \times \left\{x^n - a^n(\beta - \sqrt{\beta^2 - 1})\right\};$$

and the quadratic factors may be found by the cases already considered.

When β is less than unit, let $\beta = \cos. \theta$, and the function to be resolved will be

$$x^{2n} - 2a^n x^n \cos. \theta + a^{2n}.$$

By means of the equations (E) we get

$$r^{2n} \cos. 2n\varphi - 2a^n r^n \cos. \theta \cos. n\varphi + a^{2n} = 0,$$
$$r^{2n-1} \times \frac{\sin. 2n\varphi}{\sin. \varphi} - 2a^n r^{n-1} \times \frac{\sin. n\varphi}{\sin. \varphi} \times \cos. \theta = 0;$$

and hence

$$r = a,$$
$$\cos. 2n\varphi - 2\cos. \theta \cos. n\varphi + 1 = 0,$$
$$\frac{\sin. 2n\varphi}{\sin. \varphi} - 2\frac{\sin. n\varphi}{\sin. \varphi} \times \cos. \theta = 0.$$

But, $\cos. 2n\varphi + 1 = 2\cos.^2 n\varphi$; and $\sin. 2n\varphi = 2\cos. n\varphi \times \sin. n\varphi$; wherefore the two last equations will become

$$2\cos. n\varphi\,(\cos. n\varphi - \cos. \theta) = 0,$$
$$2\frac{\sin. n\varphi}{\sin. \varphi}(\cos. n\varphi - \cos. \theta) = 0:$$

and these, supposing $\cos. \theta$ different from unit, can be satisfied only by making $\cos. n\varphi - \cos. \theta = 0$, or

$$\cos. n\varphi = \cos. \theta.$$

Now, $\cos. \theta = \cos. (m \times 360° + \theta)$, m being any integer number whatever, zero included; and hence $\varphi = \frac{m \times 360° + \theta}{n}$, which formula comprehends all the values of θ that will satisfy the above equations. Wherefore all the factors sought will be contained in this general expression, viz.

$$x^2 - 2ax \cos. \frac{m \times 360° + \theta}{n} + a^2;$$

in which, if for m we substitute all the integer numbers less than n, zero included, we shall obtain the n quadratic factors of the proposed function.

15. The quadratic divisors $(x - \alpha)^2 - r^2$ and $(x - \alpha)^2 + r^2$, have hitherto been considered separately; but they may be both represented by $(x - \alpha)^2 - s$, which will coincide with the one or the other, according as s is positive or negative. And, if we now proceed as before, we shall get the following equations, which express the conditions necessary, in order that the polynome $f(x)$ of any proposed dimensions, as n, shall be divisible by $(x - \alpha)^2 - s$, viz.

$$0 = f(\alpha) + \frac{1}{2} \cdot \frac{d^2 f(\alpha)}{d\alpha^2} s + \frac{1}{24} \cdot \frac{d^4 f(\alpha)}{d\alpha^4} \cdot s^2 +, \&c.$$
$$0 = \frac{df(\alpha)}{d\alpha} + \frac{1}{6} \cdot \frac{d^3 f(\alpha)}{d\alpha^3} \cdot s + \frac{1}{120} \cdot \frac{d^5 f(\alpha)}{d\alpha^5} s^2 +, \&c.$$

By eliminating s we shall obtain an equation, viz.

$$A = 0,$$

in which α is the unknown quantity. As the process of elimination is independent of the particular values of the co-efficients of $f(x)$, the degree of the resulting equation will be the same when the polynome $f(x)$ has as many real roots as dimensions, and when the case is otherwise. But when $f(x)$ is equal to the product of n real binomial factors, the multiplication of every two of them will form a quadratic factor. The number of such factors will, therefore, be equal to $n \times \frac{n-1}{2}$, which expresses all the combinations made with n things taken two and two. Consequently, there will be just so many different values of α that will satisfy the equation $A = 0$, which will, therefore, have its exponent equal to $n \times \frac{n-1}{2}$. It thus appears that the equation $A = 0$ rises in its dimensions very rapidly above the given polynome, on which account little advantage is derived from this procedure.

Again, by eliminating α from the same two equations, we shall obtain one, viz.

$$S = 0,$$

in which s is the unknown quantity. This equation, which has already been alluded to (Sect. 8), rises to the same dimensions with the former equation, $A = 0$; but it is possessed of some useful properties, derived chiefly from the consideration that every positive root gives a quadratic factor of the form $(x - \alpha)^2 - r^2$ in the polynome $f(x)$, and every negative root a quadratic factor of the form $(x - \alpha)^2 + r^2$ in the same polynome.

The quadruple of s is equal to the square of the difference of the two binomial factors of $(x - \alpha)^2 - s$; whence it follows that the quadruples of the several roots of the equation $S = 0$ are equal to the squares of the differences of the roots of $f(x) = 0$. If, therefore, we put x', x'', x''', &c. for the roots of $f(x) = 0$, the roots of $S = 0$ will be

$$\frac{1}{4}(x' - x'')^2,\ \frac{1}{4}(x' - x''')^2,\ \frac{1}{4}(x'' - x''')^2,\ \&c.;$$

and from this it is manifest that the co-efficients of the same equation will be known symmetrical functions of the quantities x', x'', x''', &c. or of the roots of $f(x) = 0$. The rules formerly explained may, therefore, be employed for calculating the co-efficients of $S = 0$; and this method of forming the equation is not only more convenient than the process of eliminating, but it likewise has the advantage of enabling us to find any one co-efficient separately without computing the rest. Thus, if we put

$$K^{(n)} = (x' - x'')^2 \cdot (x' - x''')^2 \cdot (x'' - x''')^2 \cdot \&c.$$

and expand this product, and in place of the symmetrical functions of which it is composed, substitute their values in terms of the given co-efficients of $f(x) = 0$, we shall obtain the value of $K^{(n)}$; and the last term of the equation $S = 0$ will be equal to

$$\pm \frac{K^{(n)}}{2^{n(n-1)}}$$

the upper sign taking place when $n \times \frac{n-1}{2}$, the dimensions of the equation $S = 0$ is even, and the lower sign when the same number is odd.

If we suppose the given equation $f(x) = 0$ to be possessed of as many real roots as dimensions, or to have n real binomial factors, the product of every two of these will be a quadratic factor $(x - \alpha)^2 - s$, in which s is positive; wherefore, the roots of $S = 0$ will be all real and all positive. On the other hand, when the given equation $f(x) = 0$ has not as many real roots as dimensions, it will be divisible by one or more quadratic factors not resolvable into real binomial factors, and in which s is negative; consequently, the equation $S = 0$ will have one or more negative roots. It is, therefore, a property of the auxiliary equation $S = 0$, that when the roots are all real they are all positive, and when they are not all real some of them are negative. Now the rule of Descartes will enable us to find whether the roots are all positive or not; and by this means we shall discover whether the roots of the given equation $f(x) = 0$ are all real or not. From what has been said, we may lay down this rule: "The proposed equation $f(x) = 0$ will have all its roots real when the auxiliary equation $S = 0$ has as many variations from one sign to another as it has dimensions, or when its terms are alternately positive and negative; otherwise the proposed equation will have one or more quadratic factors of the form $(x - \alpha)^2 + r^2$, but the number of such factors cannot exceed the continuations of the same sign in the auxiliary equation."

Again, in the equation $S = 0$, the polynome S is equal to a certain number of binomial factors or the forms $x - a$ and $x + a$, multiplied into a supplementary polynome of even dimensions, which, not being capable of having a negative value, will have its last term positive (Sect. 5). It is manifest, therefore, that the last term of $S = 0$ will be positive or negative, according as the number of factors of the form $x - a$ is even or odd, that is, according as the equation has an even or odd number of real and positive roots. But every two real roots in the equation $f(x) = 0$ give one real and positive root in the subsidiary equation $S = 0$; wherefore, if m denote the number of real roots in the former equation, the number of real and positive roots in the latter will be equal to $m \times \frac{m-1}{2}$; and the last term of the subsidiary equation will be positive or negative, according as $m \times \frac{m-1}{2}$ is an even or an odd number.

In a cubic equation $x^3 + px + q = 0$, m is either one or three. In the first case, the equation $S = 0$ will have no positive roots, and the last term will be positive; in the second case, it will have three real and positive roots, and the last term will be negative. Now the dimensions of $S = 0$ being odd, the function $K^{(3)}$ will be negative in the first case and positive in the second. Wherefore the given cubic equation will have one real root, or three, according as the function $K^{(3)}$, that is,

$$(x' - x'')^2 \cdot (x' - x''')^2 \cdot (x'' - x''')^2,$$

or $-4p^3 - 27q^2$, is negative or positive.

In a biquadratic equation $x^4 + px^2 + qx + r = 0$, m is equal to zero, or two, or four. In the first case the equation $S = 0$ has no positive roots, in the third it has six, and in both cases the last term is positive. In the second case the same equation has only one real and positive root, and the last term is negative. The dimensions of $S = 0$, equal to $\frac{4 \times 3}{2}$, being even, the function $K^{(4)}$ will be positive in the first and third cases, and negative in the second case. Wherefore the proposed biquadratic equation will have only two real roots when the function $K^{(4)}$, that is,
$(x' - x'')^2 . (x' - x''')^2 . (x' - x^{IV})^2 . (x'' - x''')^2 . (x - x^{IV})^2 . (x''' - x^{IV})^2$, or, $256r^3 - 128p^2r^2 + 144q^2pr + 16p^4r - 27q^4 - 4q^2p^3$, is negative; and when the same function is positive, the proposed equation will have four real roots, if the terms of the auxiliary equation $S = 0$ be alternately positive and negative; otherwise it will have no real roots.

In an equation of the fifth degree, m is equal to one, or three, or five. In the first and third cases the last term of $S = 0$ will be positive, for there are either no positive roots or ten; in the second case the last term is negative, the number of positive roots being three. The dimensions of $S = 0$, equal to $\frac{5 \times 4}{2}$, being even, the function $K^{(5)}$ will be positive in the first and third cases, and negative in the second. Wherefore the given equation of the fifth degree will have three real roots when the function $K^{(5)}$ is negative; and when the same function is positive, it will have five real roots if the terms of the auxiliary equation $S = 0$ be alternately positive and negative; otherwise it will have but one.

Resolution of Algebraic Equations.

16. When the co-efficients of an equation are given in

numbers, we may investigate the numerical value of any one root separately, by first seeking the limits between which it lies, and then narrowing those limits to any required degree of approximation. But this process is not what is meant by the general solution of algebraical equations, which supposes that the co-efficients are denoted by general symbols, and consists in finding such a function of those quantities as shall, by the multiplicity of its values, represent all the roots. An algebraical expression is susceptible of many values, by means of the different radical quantities it contains; but these radical quantities being themselves the roots of an equation, it follows that the general formula for the solution of any proposed equation can be nothing more than a function of the given co-efficients combined with the roots of another equation.

The solution of quadratic equations has been known since the origin of algebra; it is found in the work of Diophantus, the first treatise on the science extant, if it be not the very first that was written. The Italian mathematicians, who are the founders of the modern algebra, discovered the solution of cubic and biquadratic equations. The rules they invented for this purpose are, however, rather the result of particular artifices than deductions from any profound views of the structure of the equations they considered. In the course of the last and the present centuries, the general solution of equations has been the subject of almost innumerable researches by all the mathematicians of the first rank; but their labours have not been successful in advancing this branch of the science beyond the steps made by the first algebraists.

The rules usually given for the solution of cubic and biquadratic equations are to be found in all the elementary books, and it would be superfluous to repeat them here. An account of the attempts that have been made to obtain a general theory for solving algebraic equations would greatly exceed the limits we must prescribe to ourselves. What has most impeded the progress of algebraists in their researches on this subject, is the difficulty of treating it by a perfect analysis, or of arriving at general conclusions by a process of reasoning founded solely on the principles of the inquiry, and disengaged from particular artifices of calculation, and from particular suppositions. In what follows we shall endeavour to lay before our readers the general principles on which is founded all that has been successfully accomplished in this theory.

Resolution of cubic equations.

Let the three roots of a cubic equation be represented by a, b, c; and having interchanged these letters among one another in all possible ways, we shall get the six permutations following, viz.—

$$abc,\quad cab,\quad bca.$$
$$acb,\quad bac,\quad cba.$$

The combinations that stand first on the left are formed by prefixing the same letter to the permutations made with the other two; and those on each line are derived from one another by making the last letter of one stand first in that which follows, while the other two letters preserve the same order.

Now let $\varrho^3 - 1 = 0$; and let the letters of first combination of each line be prefixed in order to the three terms of $1 + \varrho + \varrho^2$; then we shall get

$$t = a + b\varrho + c\varrho^2, \qquad s = a + c\varrho + b\varrho^2;$$

and if we multiply t and s by $1, \varrho, \varrho^2$ successively, we shall further obtain

$$t = a + b\varrho + c\varrho^2, \qquad s = a + c\varrho + b\varrho^2,$$
$$t\varrho = c + a\varrho + b\varrho^2, \qquad s\varrho = b + a\varrho + c\varrho^2,$$
$$t\varrho^2 = b + c\varrho + a\varrho^2. \qquad s\varrho^2 = c + b\varrho + a\varrho^2.$$

The six quantities $t, t\varrho, t\varrho^2, s, s\varrho, s\varrho^2$, comprehend all the values that can be formed by combining with $1 + \varrho + \varrho^2$, the three letters taken in any order whatever; and it is obvious that the cubes of all these six quantities, being each equal either to t^3 or s^3, have no more than two values.

And because t^3 and s^3 have only one value each, any symmetrical functions of them, as $t^3 + s^3$ and $t^3 s^3$, will have determinate values, which remain the same, however the letters a, b, c be interchanged among one another. The quantities $t^3 + s^3$ and $t^3 s^3$ must, therefore, be symmetrical functions of a, b, c; and, consequently, they can be found in terms of the co-efficients of the given equation.

By actually involving to the third power, we get

$$\begin{aligned} t^3 = a^3 + b^3 + c^3 &+ 6\,abc \\ &+ 3\,(a^2b + b^2c + c^2a)\,.\,\varrho \\ &+ 3\,(a^2c + c^2b + b^2a)\cdot\varrho^2, \\ s^3 = a^3 + b^3 + c^3 &+ 6\,abc \\ &+ 3\,(a^2c + c^2b + b^2a)\,.\,\varrho \\ &+ 3\,(a^2b + b^2c + c^2a)\,.\,\varrho^2. \end{aligned}$$

and likewise

$$\begin{aligned} (a + b + c)^3 = a^3 + b^3 + c^3 &+ 6\,abc \\ &+ 3\,(a^2b + b^2c + c^2a) \\ &+ 3\,(a^2c + c^2b + b^2a). \end{aligned}$$

Now $1 + \varrho + \varrho^2 = 0$, when ϱ is any root of $\varrho^3 - 1 = 0$ different from unit; therefore, by adding the last three expressions, we get

$$t^3 + s^3 = 3\,(a^3 + b^3 + c^3) + 18\,abc - (a + b + c)^3.$$

Again, by actually multiplying

$$\begin{aligned} ts = a^2 + b^2 &+ c^2 \\ &+ (ab + bc + ca)\,.\,\varrho \\ &+ (ab + bc + ca)\,.\,\varrho^2; \end{aligned}$$

and, because $\varrho + \varrho^2 = -1$,

$$ts = a^2 + b^2 + c^2 - (ab + bc + ca).$$

By means of the preceding formulæ, we can compute the values of $t^3 + s^3$ and $t^3 s^3$; and these values being the co-efficients of a quadratic equation having its roots equal to t^3 and s^3, we can thence find t^3 and s^3, and t and s. Now t and s being known, we have

$$a + b + c = a + b + c,$$
$$t = a + b\varrho + c\varrho^2,$$
$$s = a + c\varrho + b\varrho^2;$$

wherefore,

$$a = \frac{1}{3}(a + b + c) + \frac{1}{3}(t + s),$$

$$b = \frac{1}{3}(a + b + c) + \frac{1}{3}(t\varrho^2 + s\varrho),$$

$$c = \frac{1}{3}(a + b + c) + \frac{1}{3}(t\varrho + s\varrho^2).$$

To apply the foregoing investigation, we shall take a cubic equation, $x^3 - 3px - 2q = 0$, which is so prepared as to want the second term, then (Sect. 9)

$$a + b + c = 0,$$
$$ab + ac + bc = -3p,$$
$$a^2 + b^2 + c^2 = 6p,$$
$$a^3 + b^3 + c^3 = 6q,$$
$$abc = 2q;$$

consequently $t^3 + s^3 = 3^3 \times 2q$; $ts = 9p$, and $t^3 s^3 = 3^3 \times 3^3\,.\,p^3$. Hence

$$\frac{1}{3}t = (q + \sqrt{q^2 - p^3})^{\frac{1}{3}},$$

$$\frac{1}{3}s = (q - \sqrt{q^2 - p^3})^{\frac{1}{3}},$$

Wherefore, by substituting these values in the expressions of the roots, we get

$$a = (q + \sqrt{q^2 - p^3})^{\frac{1}{3}} + (q - \sqrt{q^2 - p^3})^{\frac{1}{3}},$$

$$b = \varrho^2\cdot(q + \sqrt{q^2 - p^3})^{\frac{1}{3}} + \varrho\,.\,(q - \sqrt{q^2 - p^3})^{\frac{1}{3}},$$

$$c = \varrho \cdot (q + \sqrt{q^2 - p^3})^{\frac{1}{3}} + \varrho^2 \cdot (q - \sqrt{q^2 - p^3})^{\frac{1}{3}}.$$

The preceding investigation, as well as all other methods that have been proposed for cubic equations, leads to the same result with the rule invented by Cardan; and, like that rule, it becomes in some cases insufficient for arithmetical computation, on account of the imaginary quantities that appear in the expressions of the roots. What is now mentioned is not an accidental circumstance, but a necessary consequence of the method of investigation pursued, and of the introduction of the imaginary roots of the equation $\varrho^3 - 1 = 0$. When a, b, c, are real quantities, the value of t and s will be both imaginary, because they involve ϱ and ϱ^2, or $\frac{-1+\sqrt{-3}}{2}$ and $\frac{-1-\sqrt{-3}}{2}$. In this case, therefore, although the three roots of the proposed equation are all real, yet the algebraic expressions of them are all imaginary, and useless for the purpose of numerical calculation; and the former circumstance is precisely the reason of the latter. On the other hand, when one root a is real and the other two imaginary, the impossible quantities destroy one another in the expressions of t and s, which are, therefore, real quantities; and in this case the algebraic formulæ answer for finding the numerical values of the roots. The distinction here pointed out depends on the radical $\sqrt{q^2 - p^3}$, which is real or imaginary, according as the equation has one or three real roots, because $q^2 - p^3$ is always positive in the first case and negative in the second.

Much labour and thought have been bestowed in order to free the formulæ for the roots of cubic equations from the imaginary expressions that render them unfit for arithmetical computation. In particular instances the difficulty disappears; namely, when the radical quantities are perfect cubes, in which cases the impossible parts of the cube roots destroy one another, so as to leave none but real quantities in the expressions of the roots of the equation. And, by expanding the radical quantities, we may in all cases obtain the roots of a cubic equation in series of an infinite number of terms free from the imaginary sign. But when it is required to transform the formulæ for the case of a cubic equation with three real roots, into finite expressions free from impossible quantities, and to do so without employing any other than the received notations of algebra, all attempts to solve the problem have led to equations in the same circumstances with the one proposed, and have ended in bringing back the same difficulty; in so much that equations of the description mentioned are said to be in the irreducible case.

It is, however, possible to transform the formulæ for the roots of a cubic equation in the irreducible case into real expressions, although not so as to fulfil all the conditions above mentioned. Let $q^2 - p^3 = y^2$; then $p = (q^2 - y^2)^{\frac{1}{3}}$: wherefore the equation $x^3 - 3px - 2q = 0$, will become

$$x^3 - 3\,(q^2 - y^2)^{\frac{1}{3}}\,x - 2q = 0 \ldots (1).$$

By the preceding formula the value of x in this equation will be

$$x = (q + y)^{\frac{1}{3}} + (q - y)^{\frac{1}{3}};$$

or, according to the notation of Section 10, making

$$n = \frac{1}{3},$$

$$x = 2\mathrm{H}_{\frac{1}{3}}\,(q, y^2).$$

By substituting this value of x, we get

$$\left\{2\,\mathrm{H}_{\frac{1}{3}}(q, y^2)\right\}^3 - 3\,(q^2 - y^2)^{\frac{1}{3}}.\left\{2\,\mathrm{H}_{\frac{1}{3}}(q, y^2)\right\} - 2q = 0;$$

which equation, being true for all values of q and y^2, must be identical, or, when expanded, must consist of a series of quantities that mutually destroy one another. Now the equation will still be identical, when y^2 is changed into $-y^2$; so that we shall have

$$\left\{2\,\mathrm{H}_{\frac{1}{3}}\,(q, -y^2)\right\}^3 - 3(q^2 + y^2)\,.^{\frac{1}{3}}\left\{2\,\mathrm{H}_{\frac{1}{3}}\,(q, -y^2)\right\} - 2\,q = 0;$$

and this proves that the equation

$$x^3 - 3\,(q^2 + y^2)^{\frac{1}{3}}\,.\,x - 2q = 0 \ldots (2)$$

is solved by the formula

$$x = 2\,\mathrm{H}_{\frac{1}{3}}\,(q, -y^2).$$

As the investigation in Section 10 is equally true, whether n be a whole or a fractional number, we may apply it to find the value of the symbol $2\mathrm{H}_{\frac{1}{3}}\,(q, -y^2)$.

For this purpose, let

$q = r \cos.\,\varphi = r \cos.\,(\varphi + 360°) = r \cos.\,(\varphi + 2\,.\,360°)$,

$y = r \sin.\,\varphi = r \sin.\,(\varphi + 360°) = r \sin.\,(\varphi + 2\,.\,360°)$;

then $r = \sqrt{q^2 + y^2}$; and, according as we take one or other of the angles that have the same sines and cosines, we shall obtain three different values of $2\mathrm{H}_{\frac{1}{3}}\,(q, -y^2)$, or of x, viz.:

$$a = 2r^{\frac{1}{3}}\,.\,\cos.\,\frac{\varphi}{3},$$

$$b = 2r^{\frac{1}{3}}\,.\,\cos.\left(\frac{\varphi}{3} + 120°\right),$$

$$c = 2r^{\frac{1}{3}}\,.\,\cos.\left(\frac{\varphi}{3} + 240°\right).$$

By putting $p = (q^2 + y^2)^{\frac{1}{3}}$, the equation (2) will assume the same form as at first, namely,

$$x^3 - 3px - 2q = 0;$$

and because $p^3 = q^2 + y^2 = r^2$, and $y = \sqrt{p^3 - q^2}$, if we determine the angles by means of their tangents instead of their sines and cosines, we shall get $\frac{\sqrt{p^3 - q^2}}{q} = \tan.\,\varphi = \tan.\,(\varphi + 360°) = \tan.\,(\varphi + 2\,.\,360°)$; and the three roots of the equation will be

$$a = 2\sqrt{p}\,.\,\cos.\,.\,\frac{\varphi}{3},$$

$$b = 2\sqrt{p}\,.\,\cos.\left(\frac{\varphi}{3} + 120°\right),$$

$$c = 2\sqrt{p}\,.\,\cos.\left(\frac{\varphi}{3} + 240°\right).$$

Every cubic equation falls under one or other of the formulæ (1) and (2), except when $y = 0$, or $p^3 = q^2$, which takes place when an equation changes from one class to another; and in this case we have

$$x^3 - 3q^{\frac{2}{3}}\,.\,x - 2q = (x - 2\,q^{\frac{1}{3}})\,.\,(x + q^{\frac{1}{3}})\,.\,(x + q^{\frac{1}{3}}).$$

The several rules that have now been given, therefore, include every possible case.

The difficulty attending the irreducible case arises from a real distinction between the two subordinate classes of cubic equations, and is insurmountable by the ordinary operations of algebra. There is no permanent distinctions of equations belonging to the same order, when we consider their roots as positive or negative; because, in any proposed equation, all the roots, or as many of them as we please, can be changed from positive to negative, by the simple artifice of increasing or diminishing them

Equations.

all by a given quantity. But the case is otherwise when we consider the roots of an equation in their character of real or imaginary quantities. No transformation can change an equation with one real root into another with three real roots, without involving the operations of the impossible arithmetic. If, therefore, we lay down this condition, namely, that the formulæ for the roots of equations must be in a shape fit for numerical calculation, we may conclude that in fact there is no resolution of equations except what consists in reducing all those of the same class to some one of that class, the most simple and convenient in its form that can be found. If we examine the preceding investigation, it will appear that it is merely an attempt to reduce all cubic equations to the form $x^3 - A = 0$; and this readily succeeds without impossible operations, when the proposed equation, and that with which it is compared, have their roots of a similar description; and it as surely fails when the case is otherwise.

In geometry, where the relations of the magnitudes under consideration are never lost sight of, there is no tendency to refer the solution of a problem to a class to which it does not belong. The ancient geometer could never be in danger of applying the problem for finding two mean proportionals to a case that can be constructed only by the trisection of an angle. The modern analyst, dismissing the original magnitudes of his problem, and reducing all possible relations to equations in abstract numbers, is apt to overlook distinctions, and sometimes to waste his labour, in seeking to accomplish what a due separation of cases would show to be impossible. There is the same distinction between the class of cubic equations with one real root, and that with three real roots, that there is between the two geometrical problems alluded to above; and the algebraist who attempts, by means of the ordinary operations of his art, to transform Cardan's formula so as to make it apply to the irreducible case, is precisely in the same situation with the geometer who should set about trisecting an angle by finding two mean proportionals.

The power and force of the algebraic method does not consist in breaking down real distinctions, but in connecting, by sure and general principles, many truths which in geometry are joined only by vague analogies, and even have no affinity at all. This advantage is derived chiefly from the doctrine of negative quantities, and from the impossible arithmetic. By means of the first, a formula which is obtained by considering only one state of the data of a problem, applies, necessarily and by the very structure of analytical language, to the same problem in all possible conditions of the data. On the other hand, when the relations of the data vary, the geometer is obliged to subdivide his problem into cases, or into other subordinate problems; and although it may be perceived that great similitude prevails among all the subdivisions, yet it is impossible to reduce the analogy between them to determinate rules, as is done in algebra. But in the whole compass of geometry there is nothing that bears any resemblance to the imaginary arithmetic. When the geometer has fixed the *determination* of his problem, or ascertained the limits within which it is possible, he has drawn a line that must be the boundary of his investigation. Now it is to truths lying beyond this line that the meaning of the comprehensive expressions of the imaginary arithmetic must be referred. It is not to be understood that a problem can be solved by algebra, which is impossible in geometry; but the analytical formulæ, at the same time that they mark the limits of the problem, go beyond them, and point out connected truths, that require only certain changes to be made in the algebraic expressions, in like manner as all the possible cases of the same problem are derived from one only, by means of the variations of the signs.

Biquadratic equations.

If a, b, c, d, represent the four roots of a biquadratic equation; and if we prefix the same letter a to all the permutations made with the other three, we shall get the six combinations following, viz.

$$\begin{array}{lll} abcd, & adbc, & acdb, \\ adcb, & acbd, & abdc. \end{array}$$

In the first line, the letters b, c, d, are made to circulate, by placing immediately after the immoveable letter a that which stands last in the combination preceding; and in the second line the moveable letters have respectively an inverted order to what they have in the first line.

Let $\varrho^2 - 1 = 0$; and let the four letters taken in the several orders of the six combinations be prefixed to the terms of $1 + \varrho + \varrho^2 + \varrho^3$; the results of the first line being t, t', t'', and those of the second line s, s', s''; then

$$\begin{array}{ll} t = a + b\varrho + c\varrho^2 + d\varrho^3, & s = a + d\varrho + c\varrho^2 + b\varrho^3, \\ t' = a + d\varrho + b\varrho^2 + c\varrho^3, & s' = a + c\varrho + b\varrho^2 + d\varrho^3, \\ t'' = a + c\varrho + d\varrho^2 + b\varrho^3, & s'' = a + b\varrho + d\varrho^2 + c\varrho^3. \end{array}$$

Now, in the equation $\varrho^2 - 1 = 0$, ϱ is either equal to $+1$ or to -1; and whether we take the one value or the other, it is apparent that $t = s$, $t' = s'$, $t'' = s''$.

Again, from every one of the six foregoing combinations, four others are derived by circulating the letters continually from the last place to the first; and in this manner we obtain twenty-four permutations, which are all that can be made with four letters. Thus, if we take $abcd$, and move the letters as directed, we shall get these four combinations, viz.

$$\begin{array}{l} abcd, \\ dabc, \\ cdab, \\ bcda. \end{array}$$

And if we multiply t by ϱ continually, observing to retain the three first powers of ϱ, and to make $\varrho^4 = 1$, we shall get

$$\begin{aligned} t &= a + b\varrho + c\varrho^2 + d\varrho^3, \\ t\varrho &= d + a\varrho + b\varrho^2 + c\varrho^3, \\ t\varrho^2 &= c + d\varrho + a\varrho^2 + b\varrho^3, \\ t\varrho^3 &= b + c\varrho + d\varrho^2 + a\varrho^3; \end{aligned}$$

so that $t, t\varrho, t\varrho^2, t\varrho^3$, are the functions formed by prefixing to $1 + \varrho + \varrho^2 + \varrho^3$, the letters of the four combinations; and it is obvious that these functions have all the same square, equal to t^2.

Wherefore, if the four letters, taken in all possible orders, be prefixed to the terms of $1 + \varrho + \varrho^2 + \varrho^3$, the squares of the twenty-four resulting functions will be equal to one or other of the six quantities, $t^2, t'^2, t''^2, s^2, s'^2, s''^2$; and since it has been proved that $t = s$, $t' = s'$, $t'' = s''$, it follows that the twenty-four squares have no more than three different values, equal to t^2, t'^2, t''^2.

And because t^2, t'^2, t''^2, can have no more than one value each, any symmetrical functions of them, viz.

$$\begin{array}{l} t^2 + t'^2 + t''^2, \\ t^2 t'^2 + t^2 t''^2 + t'^2 t''^2, \\ t^2 t'^2 t''^2, \end{array}$$

will have determinate values independent of the order of the letters a, b, c, d. The same functions will therefore be symmetrical expressions of the roots of the given biquadratic equation, and they will be known in terms of the co-efficients of that equation.

Supposing $\varrho = -1$, we get

$$\begin{aligned} t &= a - b + c - d, \\ t' &= a - d + b - c, \\ t'' &= a - c + d - b; \end{aligned}$$

and hence

$$\begin{aligned} t^2 &= a^2 + b^2 + c^2 + d^2 \\ &\quad - 2(ab + ad + bc + cd) + 2(ac + bd), \\ &= (a + b + c + d)^2 - 4\Sigma . ab + 4(ac + bd) \end{aligned}$$

the symbol $\Sigma \,.\, ab$ being used here, as in Sect. 9, to denote the sum of the products of every two of the roots. Wherefore, if we put

$$M = (a+b+c+d)^2 - 4\Sigma \,.\, ab,$$
$$m = ac+bd,$$
$$m' = ab+dc,$$
$$m'' = ad+bc,$$

then

$$t^2 = M+4m,$$
$$t'^2 = M+4m',$$
$$t''^2 = M+4m'';$$

and hence

$$t^2+t'^2+t''^2 = 3M+4(m+m'+m''),$$
$$t^2t'^2+t^2t''^2+t'^2t''^2 = 3M^2+ 8M(m+m'+m'') +16(mm'+mm''+m'm'').$$

But it will readily appear that

$$m+m'+m'' = \Sigma \,.\, ab$$
$$mm'+mm''+m'm'' = (a+b+c+d) \times \Sigma \,.\, abc - 4abcd.$$

Now, by substituting these values, we get

$$t^2+t'^2+t''^2 = 3(a+b+c+d)^2 - 8\Sigma \,.\, ab,$$
$$t^2t'^2+t^2t''^2+t'^2t''^2 = 3(a+b+c+d)^4 - 16(a+b+c+d)^2 \times \Sigma \,.\, ab + 16(a+b+c+d) \times \Sigma \,.\, abc + 16(\Sigma \,.\, ab)^2 - 64abcd.$$

Again, if we multiply the expressions of t, t', t'', we shall get

$$tt't'' = (a-c) \,.\, (a^2-c^2)+(b-d) \,.\, (b^2-d^2) - (a+c)\,(b-d)^2 - (b+d)\,(a-c)^2;$$

or, $tt't'' = a^3+b^3+c^3+d^3+2\Sigma \,.\, abc - (a^2b+a^2c+a^2d+b^2a+b^2c+b^2d+c^2a+c^2b+c^2d+d^2a+d^2b+d^2c)$;

and finally, by means of the formulæ in Sect. 9,

$$tt't'' = (a+b+c+d)^3+8\Sigma \,.\, abc - 4(a+b+c+d) \times \Sigma \,.\, ab.$$

If now we substitute the values computed by the preceding formulæ in the cubic equation

$$0 = u^3 - (t^2+t'^2+t''^2)u^2 + (t^2t'^2+t^2t''^2+t'^2t''^2)u - t^2t'^2t''^2,$$

we shall obtain the values of t^2, t'^2, t''^2, and consequently of t, t', t'', by solving that equation; and when t, t', t'', are known, we have

$$a+b+c+d = a+b+c+d,$$
$$t = a+b\varrho+c\varrho^2+d\varrho^3,$$
$$t' = a+d\varrho+b\varrho^2+c\varrho^3,$$
$$t'' = a+c\varrho+d\varrho^2+b\varrho^3;$$

wherefore, because $0=1+\varrho+\varrho^2+\varrho^3$, we get

$$a=\frac{1}{4}\left\{a+b+c+d+t+t'+t''\right\},$$
$$b=\frac{1}{4}\left\{a+b+c+d+t\varrho^3+t'\varrho^2+t''\varrho\right\},$$
$$c=\frac{1}{4}\left\{a+b+c+d+t\varrho^2+t'\varrho+t''\varrho^3\right\},$$
$$d=\frac{1}{4}\left\{a+b+c+d+t\varrho+t'\varrho^3+t''\varrho^2\right\}.$$

And finally, by making $\varrho=-1$,

$$a=\frac{1}{4}\left\{a+b+c+d+t+t'+t''\right\},$$
$$b=\frac{1}{4}\left\{a+b+c+d-t+t'-t''\right\},$$
$$c=\frac{1}{4}\left\{a+b+c+d+t-t'-t''\right\},$$
$$d=\frac{1}{4}\left\{a+b+c+d-t-t'+t''\right\}.$$

In applying these formulæ, it is necessary to observe, that as the quantities t, t', t'', are found by extracting the square root, they may each have either the sign plus or the sign minus prefixed. But all ambiguity from this cause will be taken away, if it be observed that the expressions of a, b, c, d, will always give the same results, provided the signs of t, t', t'', be so determined as to satisfy the equation,

$$tt't''=(a+b+c+d)^3+8\Sigma \,.\, abc - 4(a+b+c+d) \times \Sigma \,.\, ab.$$

For, if we suppose that the signs of t, t', t'', are so determined as to satisfy the equation mentioned, they cannot be varied so as still to satisfy the same equation, unless two of them be changed together; for, if one sign only be changed, or if all the three be changed together, the product $tt't''$ will have an opposite sign to what it had before, and the equation will no longer be satisfied. But the expressions of a, b, c, d, give the same set of values when the signs of any two of the letters t, t', t'', are changed together; so that, in order to have the true values of the quantities sought, no other rule for the signs of t, t', t'', is necessary than that they must be such as to satisfy the equations alluded to.

To apply the preceding investigation, we may take the equation

$$x^4+px^2+qx+r=0,$$

which wants the second term. Then,

$$o=a+b+c+d,$$
$$p=\Sigma \cdot ab,$$
$$-q=\Sigma \,.\, abc,$$
$$r=abcd:$$

hence

$$t^2+t'^2+t''^2=-8p,$$
$$t^2t'^2+t^2t''^2+t'^2t''^2=16p^2-64r,$$
$$tt't''=8q:$$

and t^2, t'^2, t''^2, are the roots of the cubic equation

$$u^3+8pu^2+16(p^2-4r)u-64q^2=0.$$

Having solved this equation, and found the values of t, t', t'', the signs of these quantities must next be determined so as to satisfy the equation,

$$tt't''=-8q;$$

and then we have these formulæ for computing the roots of the proposed equation, viz.

$$a=\frac{t+t'+t''}{4},$$
$$b=\frac{-t+t'-t''}{4},$$
$$c=\frac{t-t'-t''}{4},$$
$$d=\frac{-t-t'+t''}{4}.$$

These formulæ coincide with the method of solving biquadratic equations first proposed by Euler in his Algebra. But, in order to take away the ambiguity arising from the double sign of the square root, that celebrated mathematician uses two sets of expressions for the roots of the equation, viz.

$$a=\frac{t+t'+t''}{4}, \qquad a=\frac{-t-t'-t''}{4},$$
$$b=\frac{-t+t'-t''}{4}, \qquad b=\frac{t-t'+t''}{4},$$
$$c=\frac{t-t'-t''}{4}, \qquad c=\frac{-t+t'+t''}{4},$$
$$d=\frac{-t-t'+t''}{4}, \qquad d=\frac{t+t'-t''}{4},$$

of which one set is the same with the formulæ given above, and the other is obtained by changing t, t', t'', into $-t, -t', -t''$: the first set being directed to be used

Equations. when $-8q$ is positive, and the other set when the same quantity is negative. This procedure is not so simple as that we have followed, which requires only one set of formulæ. It has even been the occasion of leading into error, in as much as it makes the signs of t, t', t'', depend entirely upon the sign of the given quantity $-8q$; whereas it is indispensable that, regard being had to the nature of the quantities t, t', t'', their signs shall be determined so as to satisfy the equation $tt't'' = -8q$. This inadvertence of Euler has escaped the observation of most of the authors who have treated of biquadratic equations, and was first noticed by M. Bret, in the second volume of the *Correspondance sur l'Ecole Polytechnique.*

It may not be improper to notice briefly some of the other rules for biquadratic equations. These are chiefly two; the method of Descartes, which resolves the given equation into two quadratic factors; and the oldest method of all, invented by Louis Ferrari, a pupil of Cardan, which proceeds by transforming the given equation, so as to make it equal to the difference of two complete squares, and then extracting the square roots. However different from one another these two methods may at first seem, they are at bottom the same; and they are so far connected with that already investigated, that all the three lead to the same cubic equation.

Suppose that a, b, c, d, are the roots of the biquadratic equation

$$x^4 - Ax^3 + Bx^2 - Cx + D = 0;$$

then $x^2 - (a+b)x + ab = 0$, and $x^2 - (c+d)x + cd = 0$, are two quadratic factors, the product of which is equal to the given equation. Now,

$$A = a + b + c + d,$$
$$t = a + b - c - d;$$

wherefore, if we put $ab = p + y$, $cd = p - y$, the two factors will become

$$x^2 - \frac{1}{2}(A + t)x + p + y = 0,$$

$$x^2 - \frac{1}{2}(A - t)x + p - y = 0:$$

and if we multiply them, and equate the co-efficients of the product to the co-efficients of the given equation, we shall get

$$2p + \frac{1}{4}A^2 - \frac{1}{4}t^2 = B,$$
$$Ap + ty = C,$$
$$p^2 - y^2 = D.$$

And it is to be observed that, on account of the first two of these equations, p and y are both real quantities when t is a real quantity; so that, provided a real value of t can be found, the given equation is always resolved, by this method, into two quadratic factors free from imaginary expressions.

Now, by combining the equations just found, we shall get

$$\begin{aligned} 0 = t^6 &- (3A^2 - 8B) \cdot t^4 \\ &+ (3A^4 - 16A^2B + 16B^2 + 16AC - 64D) \cdot t^2 \\ &- (A^3 - 4AB + 8C)^2, \end{aligned}$$

$$p = \frac{1}{2}B - \frac{1}{8}A^2 + \frac{1}{8}t^2$$

$$y = \sqrt{\left(\frac{1}{2}B - \frac{1}{8}A^2 + \frac{1}{8}t^2\right)^2 - D}.$$

The first of these equations is a cubic, of which the root is t^2; and it is precisely the same with the cubic of the former method. As the last term of this equation is essentially positive, it follows that there is always one positive value of t^2, and one real value of t; wherefore, in consequence of what has been proved, the values of p and y, derived from the positive value of t^2, are in every case real quantities, which is no doubt an advantage in the practical application of the method. Equations.

If we wish to follow the process of Louis Ferrari, we may assume p, t, y, so as to render the expression

$$\left(x^2 - \frac{1}{2}Ax + p\right)^2 - \left(\frac{1}{2}tx + y\right)^2 = 0$$

identical with the given equation; and as this expression is no more than the product of the two quadratic factors of the last method, the quantities to be determined will be found by the formulæ already given.

Equations of the fifth degree.

The theory of permutations, which is successful in solving cubic and biquadratic equations, applies likewise to those of the fifth and higher orders. But, to use the words of Lagrange, "Passé le quatrième degré, la méthode, quoiqu' applicable en général, ne conduit plus qu'à des équations resolvantes de degres superieurs à celui de la proposée." Thus, in the case of equations of the fifth degree, the theory leads to a biquadratic equation, of which the co-efficients are to be found by resolving an equation of the sixth order.

There is, however, no doubt that the doctrine of permutations contains the principles from which we are to expect the resolution of equations of the higher orders, if the problem be possible. It may be alleged, with great probability, that the theory succeeds in the less complicated cases, because when the number of the roots is small, their permutations are soon exhausted, and we speedily arrive at those combinations of them which remain invariable, whatever be the order of the quantities combined. But when the number of the roots is greater than four, their permutations are very numerous, and at the same time the functions produced by combining them are very complicated; on which accounts it is difficult to conduct the investigation so as to arrive at a satisfactory conclusion, either accomplishing the intended purpose, or proving that the undertaking is impossible.

In the twelfth volume of the *Italian Society*, and in a work published at Modena in 1813, M. Paolo Ruffini has proved that no function of five letters can exist that is susceptible of only three or four different values when the letters are interchanged among one another in all possible ways. M. Cauchy, in the sixteenth volume of the *Journal de l'Ecole Polytechnique*, has demonstrated that a function of n letters, unless it have no more than two different values, cannot have a number of different values less than the prime number next below n. On these grounds it has been inferred that the resolution of equations of the fifth degree is in reality an impossible problem. (Lacroix, *Compt. des Elem. d'Algebre*, p. 61.) And if it be admitted that, in the process of resolution, no equations can occur except such as have symmetrical functions of the five letters for their co-efficients, the inference founded on the labours of the eminent mathematicians we have mentioned would be indisputable. But it is not impossible that the resolution of equations of a high order must be effected by gradually depressing an equation at first of great dimensions; and in this procedure we may arrive at equations, the co-efficients of which, although functions of the roots of the proposed equation, are not symmetrical functions, but partial expressions, susceptible of several values, according as the order of the letters that denote the roots is made to vary. On this supposition, the resolution of equations above the fourth order, by means of equations inferior in degree, would not be inconsistent with what has been proved.

Some particular classes of equations.

17. A method for solving equations of one order may be generalized so as to extend to a certain class in all orders. Thus De Moivre has found a species of equations

of every degree that have their roots similar to those of cubics, and which are solved by the formula

$$x = (q + \sqrt{q^2 - p^n})^{\frac{1}{n}} + (q - \sqrt{q^2 - p^n})^{\frac{1}{n}},$$

differing in no respect from the expression for resolving cubics, except that n is written in place of 3.

An equation may be depressed to a lower order when it is known that the roots have a given relation to one another. An instance of this has already occurred in the case of equal roots; for, the equal roots having been first found, the equation can be lowered by division. Reciprocal equations furnish another example of depression to a lower order, on account of a relation subsisting among the roots. A reciprocal equation is one of even dimensions, such that half the roots are respectively the reciprocals of the other half, in which case no alteration is produced in the equation when $\frac{1}{x}$ is substituted for x. In equations of this kind, the same co-efficients occur in the same order, and with the same signs, reckoning from either end; a description that likewise applies to some equations of odd dimensions, which, however, do not constitute a new class, being merely reciprocal equations, as defined above, multiplied by the factor $x + 1$. A reciprocal equation may always be depressed to half the dimensions, by transforming it so that the new unknown quantity shall be equal to $x + \frac{1}{x}$. It is sufficient to have mentioned these cases, which are fully treated of in all the elementary books.

Equations with only two terms, as $x^p - 1 = 0$, are the most extensive class that have been resolved by a general method. The successful application of analysis to this class of equations is extremely interesting, both in itself, and likewise because it is connected with the division of the circle into equal parts, and has occasioned the discovery of some curious and unexpected results respecting that problem. For these reasons, it appears proper to lay before our readers a short view of this branch of the doctrine of algebraic equations.

We have already shown, that, admitting the theory of angular sections, every equation with only two terms, as $x^p - 1 = 0$, may be completely resolved into its binomial and trinomial factors; and hence all its roots, possible and impossible, may be computed by means of the trigonometrical tables in common use. If we put $\varphi = \frac{360°}{p}$, and denote by k any number less than $\frac{1}{2}p$, we have found that the equation $x^p - 1 = 0$ is divisible by the quadratic factor $x^2 - 2x$, $\cos. \varphi + 1$, and, consequently, that it has the two impossible roots,

$$x = \cos. k\varphi + \sin. k\varphi . \sqrt{-1},$$
$$x = \cos. k\varphi - \sin. k\varphi . \sqrt{-1}:$$

and, because $\cos. k\varphi = \cos. (p-k)\varphi$, and $-\sin. k\varphi = \sin. (p-k)\varphi$, the same two roots may be otherwise more symmetrically represented thus,

$$x = \cos. k\varphi + \sin. k\varphi . \sqrt{-1},$$
$$x = \cos. (p-k)\varphi + \sin. (p-k)\varphi . \sqrt{-1}.$$

Therefore, when p is odd, the equation $x^p - 1 = 0$ has one real root equal to 1; and when p is even, it has two real roots equal to ± 1; and in both cases the remaining roots are all impossible, and are found from the formula

$$x = \cos. k\varphi + \sin. k\varphi . \sqrt{-1},$$

by making k equal to all the integral numbers less than p in the one case, and less than $p - 1$ in the other. Nothing, therefore, can be more simple than the computation of the roots of such equations by means of the trigonometrical tables. But in seeking a general solution, it is required to investigate the roots without resorting to the properties of the circle, unless in so far as this may be necessary for solving similar equations inferior in degree to the one proposed. In this view the resolution of the equation $x^p - 1 = 0$, is equivalent to the division of the circle into p equal parts, granting the like division for all numbers less than p. And in order to render the investigation of the problem as simple as possible, it may be further observed, that it will be sufficient to consider the case when the exponent is a prime number; because, from this case, the other, when it is a composite number, can be readily deduced.

It will be proper to premise here a property of the roots of equations with only two terms, to which we shall have occasion continually to refer. The property in question depends upon this theorem, namely, when k is any number not a multiple of the prime number p, the remainders of the terms of the series

$$1 \times k, 2 \times k, 3 \times k \ldots (p-1) \times k,$$

when each is divided by p, are all different from one another; and, consequently, without regard to the order, they will coincide with the numbers 1, 2, 3, &c. less than p. If, therefore, we take any one of the impossible roots of the equation $x^p - 1$, viz.

$$r = \cos. k\varphi + \sin. k\varphi \sqrt{-1},$$

all its powers with indices less than p, viz.

$$r^2 = \cos. 2k\varphi + \sin. 2k\varphi . \sqrt{-1},$$
$$r^3 = \cos. 3k\varphi + \sin. 3k\varphi . \sqrt{-1},$$
&c.

will be different from one another; and likewise they will coincide, without regard to the order, with the like powers of any other impossible root of the same equation: because, whatever number k stands for, the arcs are all different from one another, and, neglecting whole circumferences, constitute the same series of terms, although in different orders. Wherefore, p being a prime number, if r be one of the impossible roots of the equation $x^p - 1 = 0$, all the roots will be represented by the terms of the geometrical progression

$$r^0, r^1, r^2, r^3, \ldots . r^{p-1};$$

for every one of these terms satisfies the given equation, and it has been shown that they are all different from one another.

When p is a composite number, the same property does not belong to all the roots of the equation $x^p - 1 = 0$, but only to some of them. It belongs generally to the root

$$r = \cos. k\varphi + \sin. k\varphi . \sqrt{-1},$$

when k is either equal to unit, or to any number that has no common divisor with p; in which cases all the powers of r are roots of the equation $x^p - 1 = 0$, and all different from one another, when the exponents are different and less than p.

If the equation $x^p - 1 = 0$ be divided by the binomial factor $x - 1$, we shall get

$$x^{p-1} + x^{p-2} + x^{p-3} \ldots . + x + 1 = 0;$$

and this being a reciprocal equation, it can be farther depressed to half the dimensions. In this manner we obtain the solution of $x^7 - 1 = 0$, which is reduced to a cubic; but, by the same procedure, the equation next in order,

viz. $x^{11}-1=0$, can be lowered only to the fifth degree, for equations of which class there is no rule. Nevertheless this last equation has been solved by Vandermonde, to whom, and to Lagrange, we are mainly indebted for disengaging the resolution of equations from the complicated operations of algebra, and for substituting, in their place, reasonings founded on the doctrine of combinations. The author has not explained particularly the process by which his solution was obtained; he gives it as a result of his theory, which, although it fails in general for equations above the fourth degree, succeeds in this instance on account of particular relations between the roots. Similar relations subsist between the roots of any other binomial equation when the exponent is a prime number; and, in consequence, a like mode of investigation will apply, as indeed the author has expressly said. But this procedure would unavoidably be attended in every new instance with very long calculations; and it appears hardly possible to arrive in this way at any general method that would apply to all equations of the class in a regular manner, and without considerations drawn from each particular case.

M. Gauss, in a work entitled *Disquisitiones Arithmeticæ*, replete with original and important matter, applied a property of prime numbers to the solution of binomial equations, which removed every difficulty, and led to a theory that unites simplicity and generality. If we suppose that p is a prime number, and resolve $p-1$ into its component factors, so that $p-1=a^{\lambda}.b^{\mu}.c^{\gamma}$. &c., a, b, c, &c. being prime numbers, M. Gauss has proved that the solution of the equation $x^p-1=0$, or, which is the same thing, the division of the circle into p equal parts, can be effected by solving successively λ equations of a dimensions, μ equations of b dimensions, γ equations of c dimensions, &c. Thus, if $p=13$, then, because $13-1=3\times 2^2$, the roots of $x^{13}-1=0$ can be found, or a polygon of 13 sides can be inscribed in a circle, by solving a cubic and two quadratic equations in succession. In certain cases, when a prime number comes under the form 2^n+1, as 17, 257, &c. the division of the circle will require the solution of equations no higher than the second order; whence this unexpected consequence has resulted from the theory of M. Gauss, that the inscription of a polygon of 17, or 257 sides in a circle, which are problems that have always been understood to transcend the limits of the elementary geometry, can, nevertheless, be constructed by the operations admitted in that science.

A work replete with so many interesting discoveries as the *Disquisitiones Arithmeticæ* could not fail to excite the attention of mathematicians. Legendre, in republishing his *Essay on the Theory of Numbers*, has added to it an exposition of M. Gauss's theory of binomial equations; and the same theory is the subject of the 14th note in the second edition of Lagrange's *Treatise on Numerical Equations*. No part of the mathematics could pass through the hands of men of so much ability without receiving great improvement. Lagrange has shown that it is not necessary to go through the several intermediate equations that make so essential a part in the investigation of M. Gauss; and, by this means, he has reduced the solution of equations with two terms to the utmost simplicity of which it is capable. But, in one respect, it must be admitted that the procedure of the illustrious geometer is imperfect. Although it arrives, by a short investigation, at the partial quantities that by their additions form the expressions of the roots sought, it leaves indeterminate the order in which they are to be combined. M. Gauss has avoided ambiguity in this respect by deducing from one of the quantities all the other parts of the same expression; but, amidst a multiplicity of different systems of values that may be deduced from the partial quantities, Lagrange has given no clue to guide to the true one.

In laying before our reader some account of this interesting branch of the theory of algebraic equations, we shall view the subject in a light somewhat different from that in which it has hitherto been placed. Instead of seeking directly the roots of binomial equations, we shall apply the principles of M. Gauss's theory immediately to the division of the circle into equal parts, by taking the arcs of the circumference in that order to which the method owes all its success. This procedure is attended with some advantages. In the first place, the algebraic expressions of the quantities sought, represented by $\cos.\frac{k\times 360°}{p}$, are more simple than those of the imaginary roots of the corresponding binomial equation; and, in the second place, the same expressions, having always real values, are better fitted for application than the roots of binomial equations, which require to be further reduced to prepare them for calculation.

Before entering on the principal problem, it is necessary to say something of that property of numbers on which the whole theory depends. Supposing p to be any prime number, Euler has distinguished by the name of a *Primitive Root* any number less than $p-1$, such that, if we take the series of all its powers with indices less than p, and in each power reject the multiples of p it contains, the several remainders are all different from one another, and, consequently, paying no regard to the order, they will coincide with the numbers 1, 2, 3, &c. less than p. It has been proved that, for every prime number, there are as many primitive roots as there are numbers less than $p-1$, which have no common divisor with it. The existence of such numbers in every case is therefore demonstrated; but no direct method of finding them has yet been published with which we are acquainted.

We gladly seize the present occasion of laying down a rule for finding the primitive roots of a prime number. But first we must premise, that when any proposed number is said to satisfy the equation $x^m+1=0$, it is always understood that the multiples of the prime number p are rejected; and the meaning is, that, when the given number is substituted for x, the whole result is divisible by p without any remainder.

Now, let p be a prime number, and 2, a, b, c, &c. the prime divisors of $p-1$, so that $p-1=2^{\pi}.a^{\lambda}.b^{\mu}.c^{\gamma}$. &c.: then every primitive root will satisfy the first of the following equations without satisfying any of the rest, viz.

$$x^{\frac{p-1}{2}}+1=0,$$
$$x^{\frac{p-1}{2a}}+1=0,$$
$$x^{\frac{p-1}{2b}}+1=0,$$
$$x^{\frac{p-1}{2c}}+1=0,$$
&c.

And, on the other hand, every number not a primitive root, which satisfies the first equation, will at the same time satisfy one, or more, or all, of the other equations.

But the numbers which satisfy the first equation are exclusively those which are not found among the remainders of the series of square numbers divided by p.

Wherefore, setting aside the first equation, if we seek among the non-residual numbers for such as satisfy none of the remaining equations, the numbers so found will be the primitive roots sought.

When one primitive root is found by this method, all the rest may be directly obtained from it. For, if 1, w, w', w'', &c. . . . $n^{(n)}$, represent all the numbers less than $p-1$ and prime to it; then a being one of the primitive roots, all the roots will be equal to the series of powers,

$$a, a^w, a^{w'}, a^{w''}, \ldots\ldots a^{w^{(n)}},$$

rejecting always the multiples of p.

The demonstration of these properties would lead us aside from our present purpose; and we shall be content with adding some examples for the sake of illustration.

Let $p=11$: then $\frac{p-1}{2}=5$, and $\frac{p-1}{2.5}=1$; so that in this case, the only equation of exclusion is $x+1=0$, which admits only one solution, viz. $x=p-1=10$. Therefore all the non-residual numbers except 10 are the primitive roots; namely, 2, 6, 7, 8. We may extend this conclusion to every case when $\frac{p-1}{2}$ is a prime number, as 7, 23, 47, &c.; in all which instances all the non-residuals, except $p-1$, are the primitive roots.

Next, let $p=17$; then $\frac{p-1}{2}=8=2^3$; and there are no equations of exclusion. In this case, therefore, all the non-residuals, without exception, are primitive roots; and the same thing is true of every prime number of the form 2^n+1, such as 5, 257, &c.

Let $p=13$; then $\frac{p-1}{2}=2\times 3$; and the only equation of exclusion is

$$x^2+1=0,$$

which admits only two solutions, viz. $x=5$ and $x=8$. In this instance, therefore, all the non-residual numbers, except 5 and 8, are the primitive roots.

Let $p=31$; then $\frac{p-1}{2}=3\times 5$; and we have two equations of exclusion, viz.

$$x^3+1=0,$$
$$x^5+1=0.$$

The non-residual numbers are

3, 6, 11, 12, 13, 15, 17, 21, 22, 23, 24, 26, 27, 29, 30.

Of these numbers the first, viz. 3, is a primitive root, since it satisfies neither of the two equations; and as the numbers less than 30, and prime to it, are 1, 7, 11, 13, 17, 19, 23, 29; all the primitive roots of 31 are as follows: viz. $3^1=3$, $3^7=17$, $3^{11}=13$, $3^{13}=24$, $3^{17}=22$, $3^{19}=12$, $3^{23}=11$, $3^{29}=21$. With respect to the other non-residual numbers, it will be found on trial that the first equation is satisfied by 6 and 26; the second by 15, 23, 27, 29; and both equations by 30.

We are now prepared to enter upon the solution of the problem for dividing the circle into as many equal parts as there are units in the prime number $p=2n+1$. If we conceive a polygon of p sides, to be inscribed in a circle, it will be admitted that the centre of gravity of the polygon coincides with the centre of the circle. Wherefore, if perpendiculars be drawn to any diameter of the circle from all the angles of the polygon, it follows, from the nature of the centre of gravity, that the sum of the cosines lying on one side of the centre of the circle will be equal to the sum of the cosines lying on the other side. Let $\varphi=\frac{360°}{p}$; and put u for the arc intercepted between the diameter and any angle of the polygon, then we shall have this equation, viz.

$$0=\cos.u+\cos.(\varphi+u)+\cos.(2\varphi+u)\ldots.+\cos.(2n\varphi+u),$$

which is no more than the analytical expression of the geometrical property just mentioned. Now, suppose that the diameter passes through one of the angles of the polygon; then $u=0$, and the equation becomes

$$0=1+\cos.\varphi+\cos.2\varphi+\cos.3\varphi\ldots.+\cos.2n\varphi.$$

Let a be one of the primitive roots of the prime number p; then rejecting multiples of p, and paying no regard to the order, the terms of the geometrical progression,

$$a, a^2, a^3, a^4\ldots\ldots a^{2n},$$

will be equal to the several numbers less than p. Wherefore, in the two series of arcs,

$$a\varphi, a^2\varphi, a^3\varphi, a^4\varphi\ldots\ldots a^{2n}\varphi,$$
$$\varphi, 2\varphi, 3\varphi, 4\varphi\ldots\ldots 2n\varphi,$$

every arc in the geometrical progression will either be equal to some one in the arithmetical progression, or will differ from it by a whole circumference, or circumferences. Hence the cosines of the first series of arcs may be substituted in the last equation for the cosines of the other series; and thus we have

$$-1=\cos.a\varphi+\cos.a^2\varphi+\cos.a^3\varphi\ldots+\cos.a^{2n}\varphi.$$

Again, by Fermat's theorem, $a^{2n}-1=(a^n+1)(a^n-1)$ $=$ a multiple of p; and because no primitive root of a prime number is the remainder of a square divided by that number, we have $a^n+1=$ a multiple of p; and consequently $a^{n+\lambda}+a^{\lambda}=$ a multiple of p. It follows, therefore, that $a^{n+\lambda}\varphi+a^{\lambda}\varphi$ is equal to a multiple of the circumference of the circle; and hence,

$$\cos.a^{n+\lambda}\varphi=\cos.a^{\lambda}\varphi \qquad \text{(A)}$$

From this it appears that the cosines in the last equation may be distributed into two equal sums; one containing the cosines of all arcs from $a\varphi$ to $a^n\varphi$ inclusively, and the other the remaining cosines; consequently

$$-\frac{1}{2}=\cos.a\varphi+\cos.a^2\varphi+\cos.a^3\varphi\ldots\cos.a^n\varphi;$$

and because $\cos.a^n\varphi=\cos.\varphi$,

$$-\frac{1}{2}=\cos.\varphi+\cos.a\varphi+\cos.a^2\varphi\ldots..+\cos.a^{n-1}\varphi. \quad (1)$$

Let $r=\frac{360°}{n}$; and put

$$e=\cos.r+\sin.r\sqrt{-1};$$

then all the powers of e with indices less than n will be different from one another, and all of them roots of the equation $e^n-1=0$, the solution of which requires the division of the circle into only n, or $\frac{p-1}{2}$, equal parts.

In what follows, we shall have continual occasion to consider the expression

$$\cos.a^{\lambda}\varphi+e^m\cos.a^{\lambda+1}\varphi+e^{2m}\cos.a^{\lambda+2}\varphi\ \ldots\ +e^{(n-1)m}\cos.a^{\lambda+n-1}\varphi;$$

and it will therefore be convenient to adopt an abridged mode of writing it. Now, the expression will be wholly known, and can be constructed when the two indices λ and m are given; and we may therefore denote it by the symbol $f(\lambda, m)$, placing always the index of a before the other. We shall invariably make the index of a positive, and suppose it reduced below n by means of the formula (A). In like manner we shall suppose that the index of e is always reduced below n by

suppressing the multiples of n; and we shall write it sometimes positive and sometimes negative, observing that the negative indices may be always rendered positive by supplying the proper multiples of n; thus,

$$e^{-im} = e^{n-im} = e^{2n-im} = e^{3n-im}, \text{ \&c.}$$

According to the notation just explained, we have

$$f(o,m) = \cos.\varphi + e^{m}\cos.a\varphi + e^{2m}\cos.a^2\varphi\ldots + e^{(n-1)m}\cos.a^{n-1}\varphi,$$

$$f(o,-m) = \cos.\varphi + e^{-m}\cos.a\varphi + e^{-2m}\cos.a^2\varphi\ldots + e^{-(n-1)m}\cos.a^{n-1}\varphi.$$

And because $e^{o} = e^{n} = e^{-n} = 1$, the symbols $f(o,o)$, $f(o,n)$, $f(o,-n)$, will represent the series of cosines in the equation (1); so that we have

$$-\frac{1}{2} = f(o,o) = f(o,n) = f(o,-n).$$

The following formula is no more than a corollary from the preceding notation, viz.

$$e^{-\lambda m}\times f(o,m) = f(\lambda,m). \quad \text{(B)}$$

By means of the trigonometrical formula in common use, any powers and products of the cosines of the arc φ and its multiples may be reduced to a series of terms, containing the like cosines multiplied by given co-efficients. Wherefore, because $\cos.p\varphi = 1$, and likewise because the cosines of all arcs greater than $p\varphi$, $2p\varphi$, $3p\varphi$, &c. may be reduced to the cosines of arcs less than $p\varphi$, it follows that every rational and integral function of $\cos.\varphi$, $\cos.2\varphi$, $\cos.3\varphi$, &c. may be brought under this form of expression, viz.

$$A + B\cos.\varphi + C\cos.2\varphi + D\cos.3\varphi\ldots + N\cos.2n\varphi.$$

Now, if we suppose the function we are considering to be such, that it retains the same value when any of the multiple arcs 2φ, 3φ, &c. is substituted for φ, the transformed expression will be possessed of the same property. But if we actually substitute the arcs 2φ, 3φ, &c. for φ in the foregoing expression, it will become successively

$$A + B\cos.2\varphi + C\cos.4\varphi + D\cos.6\varphi +, \text{\&c.}$$
$$A + B\cos.3\varphi + C\cos.6\varphi + D\cos.9\varphi +, \text{\&c.}$$
&c.

each line containing the same cosines, although in a different order, because the series of arcs is the same when whole circumferences, or the multiples of $p\varphi$, are rejected; and all these expressions cannot have the same value unless $B = C = D =$ &c.; that is, unless the expression be of this form, viz.

$$A + B(\cos.\varphi + \cos.2\varphi + \cos.3\varphi\ldots + \cos.2n\varphi),$$

which, in consequence of what was before proved, is equal to $A - B$. It is therefore demonstrated that every rational and integral function of $\cos.\varphi$, $\cos.2\varphi$, $\cos.3\varphi$, &c., which remains unchanged when any of the multiple arcs 2φ, 3φ, &c. is substituted for φ, has for its value an expression without cosines, and depending only upon the nature of the function.

If we introduce the arcs in geometrical instead of those in arithmetical progression, it is obvious that the substitution of the multiple arcs 2φ, 3φ, &c., for φ, is equivalent to the changing of φ into $a\varphi$, $a^2\varphi$, $a^3\varphi$, &c.; and hence any rational and integral function of the cosines of φ and its multiples, which remains invariable when φ is changed into $a\varphi$, $a^2\varphi$, $a^3\varphi$, &c. is a quantity independent of the cosines, or has its value expressed by a function from which the cosines are eliminated.

What has now been proved will enable us to appreciate the advantage arising from the introduction of the arcs in geometrical in place of those in arithmetical progression, in which principally consists the improvement that this theory owes to M. Gauss. The solution of the problem turns upon finding those functions of $\cos.\varphi$, $\cos.2\varphi$, $\cos.3\varphi$, &c. which have determinate values independent of the cosines; which functions, it has been proved, remain invariable when any of the multiple arcs 2φ, 3φ, &c. is substituted for φ. Now, although the substitution of any multiple arc, in place of the arc itself, always reproduces the same series of cosines, yet the order is irregular, and varies with every different multiple arc; and this circumstance makes it difficult to investigate what change the substitution will effect in a given function. On the other hand, by introducing the arcs in geometrical progression, the same order is still preserved, whatever substitution be made; and by this means every facility possible is obtained for investigating the functions sought.

The following properties are deducible from what has been proved. First, if m, m', m'', &c. be any numbers, none of which is equal to zero, or a multiple of n, and such that their sum is equal to n, or to a multiple of n, the product

$$f(o,m)\times f(o,m')\times f(o,m''), \text{\&c.}$$

will be independent of the cosines of φ and its multiples, or will be an expression containing only the powers of e multiplied by numeral co-efficients.

For by the formula (B) we have

$$e^{-\lambda m}\times f(o,m) = f(\lambda,m)$$
$$e^{-\lambda m'}\times f(o,m') = f(\lambda,m')$$
$$e^{-\lambda m''}\times f(o,m'') = f(\lambda,m'')$$
&c. &c.

Therefore, by multiplying and observing that $e^{-\lambda m}\times e^{-\lambda m'}\times e^{-\lambda m''}\times$, &c. $= 1$, because $\lambda\times(m + m' + m'' +$, &c.) is a multiple of n, we get

$$f(o,m)\times f(o,m')\times f(o,m''), \text{\&c.} = f(\lambda,m)\times f(\lambda,m')\times f(\lambda,m''), \text{\&c.}$$

which shows that the product in question is not altered when φ is changed into $a^{\lambda}\varphi$. Consequently, according to what was before proved, the product is independent of the cosines.

It follows, as a corollary, that the product

$$f(o,m)\times f(o,-m)$$

is independent of the cosines.

Next, if m, m', m'', &c. be any numbers, and $s = m + m' + m''$, &c.; and if neither s nor any of the numbers m, m', m'', &c. be a multiple of n, we shall have

$$f(o,m)\times f(o,m')\times f(o,m''), \text{\&c.} = M\times f(o,s),$$

the quantity M being independent of the cosines, and containing only the powers of e multiplied by numeral co-efficients.

For, by the property already demonstrated, and its corollary, we have

$$f(o,m)\times f(o,m')\times f(o,m'')\times f(o,-s) = A$$
$$f(o,s)\times f(o,-s) = A';$$

A and A′ being quantities independent of the cosines. Therefore, by exterminating $f(o,-s)$, we get

$$f(o,m)\times f(o,m')\times f(o,m'')\times, \text{\&c.} = \frac{A}{A'}.f(o,s).$$

The foregoing properties are the foundations of the theory. But it is not enough to establish the principles by a general demonstration; it is also necessary to be able to compute the numerical values that occur in the application to particular problems. Therefore, supposing that m and m' are two numbers, and $s = m + m'$, none of the

three numbers s, m, m', being a multiple of n, it is proposed to find the value of A in the equation

$$f(o, m) \times f(o, m') = \mathrm{A} \times f(o, s).$$

For this purpose, set down the several terms of $f(o, m')$ in their order; and below them write the terms of $f(o, m)$, placing first any term, as $e^{\lambda m} \cos. a^{\lambda}\varphi$, and the rest in their order, in this manner:

$$\cos.\varphi + e^{m'}\cos.a\,\varphi + e^{2m'}\cos.a^2\varphi \ldots\ldots + e^{(n-1)m'} \cos.a^{n-1}\varphi,$$

$$e^{\lambda m}\cos.a^{\lambda}\varphi + e^{(\lambda+1)m}\cos.a^{\lambda+1}\varphi + e^{(\lambda+2)m}\cos.a^{\lambda+2}\varphi \,.\,. + e^{(\lambda+n-1)m}\cos.a^{\lambda+n-1}\varphi.$$

Now, let every term in the lower line be multiplied into that which stands above it; and, separating the factor $e^{\lambda m}$, which is common to each product, let the symbol $e^{\lambda m} \times \Psi(\lambda)$ represent the sum of all the products; then

$$\Psi(\lambda) = \cos.\varphi\cos.a^{\lambda}\varphi + e^{s}\cos.a\,\varphi\cos.a^{\lambda+1}\varphi \ldots . + e^{(n-1)s}\cos.a^{n-1}\varphi\cos.a^{\lambda+n-1}\varphi.$$

If we repeat this operation, so as to make every term of the lower line stand first in succession, it is evident that, by this means, every term of $f(o, m')$ will be multiplied by all the terms of $f(o, m)$; so that the sum of all the results will be the product sought. We therefore obtain

$$f(o, m) \times f(o, m') = \Psi(o) + e^{m}\Psi(1) + e^{2m}\Psi(2) \ldots + e^{(n-1)m}\Psi(n-1).$$

Let $a^{\lambda} + 1 = w$, and $a^{\lambda} - 1 = w'$; then, because the product of the cosines of the two arcs is equal to half the sum of the cosines of the sum and difference of the two arcs, we shall have

$$\Psi(\lambda) = \frac{1}{2}\left\{\cos.w\varphi + e^{s}\cos.a\,.\,w\varphi + e^{2s}\cos.a^2\,.\,w\varphi +, \&c.\right\} + \frac{1}{2}\left\{\cos.w'\varphi + e^{s}\cos.a\,.\,w'\varphi + e^{2s}\cos.a^2.w'\varphi +, \&c.\right\}.$$

In the first place, when $\lambda = 0$, $w = 2$, $w' = 0$; therefore

$$\Psi(o) = \frac{1}{2}\left\{\cos.2\varphi + e^{s}\cos.a\,.\,2\varphi + e^{2s}\cos.a^2\,.\,2\varphi \ldots . e^{(n-1)s}\cos.a^{n-1}\,.\,2\varphi\right\} + \frac{1}{2}\left\{1 + e^{s} + e^{2s} + e^{3s} \,.\,. + e^{(n-1)s}\right\}.$$

But $e^{n} - 1 = 0$; and hence $e^{ns} - 1 = 0$; or

$$0 = (1 - e^{s}) . \left\{1 + e^{s} + e^{2s} +, \&c. \ldots + e^{(n-1)s}\right\}:$$

and, according to the value assumed for e, the equation $1 - e^{s} = 0$ cannot take place when s is not a multiple of n; wherefore

$$0 = 1 + e^{s} + e^{2s} + e^{3s} \ldots + e^{(n-1)s}.$$

Now, if we put $a^{i} = 2$, we shall get

$$\Psi(o) = \frac{1}{2}f(i, s) = \frac{1}{2}\left\{\cos.\,.a^{i}\varphi + e^{s}\cos.a^{i+1}\varphi + e^{2s}\cos.a^{i+2}\varphi +, \&c.\right\}$$

Wherefore, on account of the formula (B), we finally get

$$\Psi(o) = \frac{1}{2}e^{-is} \times f(o, s).$$

Next, when λ is not equal to zero, let $h(\lambda)$ and $h(\lambda)$ denote the numbers derived from λ by means of the equations

$$a^{\lambda} + 1 = a^{h(\lambda)},$$

$$a^{\lambda} - 1 = a^{h'(\lambda)};$$

then, by substituting $a^{h(\lambda)}$ and $a^{h'(\lambda)}$ for w and w', we shall get

$$\Psi(\lambda) = \frac{1}{2}f\Big(h(\lambda), s\Big) + \frac{1}{2}f\Big(h'(\lambda), s\Big):$$

and, on account of the formula (B),

$$\Psi(\lambda) = \left\{\frac{1}{2}e^{-(\lambda)s} + \frac{1}{2}e^{-h'(\lambda)s}\right\}.f(o, s).$$

Now, collecting all the parts in the expression of $f(o, m) \times f(o, m')$, we shall get these formulæ, viz.:

$$\left.\begin{aligned} &f(o, m) \times f(o, m') = \mathrm{A} \times f(o, s) \\ &\mathrm{A} = \frac{1}{2}e^{-is} + \frac{1}{2}e^{m-h(1)s} + \frac{1}{2}e^{m-h'(1)s} \\ &\qquad + \frac{1}{2}e^{2m-h(2)s} + \frac{1}{2}e^{2m-h'(2)s} \\ &\qquad + \frac{1}{2}e^{3m-h(3)s} + \frac{1}{2}e^{3m-h'(3)s} \\ &\qquad\quad \&c. \qquad\qquad \&c \end{aligned}\right\} \quad (2)$$

As nothing changes in the expression of A except the indices m and s, it may be denoted by the abridged symbol (m, s), in which it is obvious that m' may be substituted for m; so that

$$\mathrm{A} = (m, s) = (m', s).$$

When s is equal to n, and $m' = n - m$, the product in question becomes $f(o, m) \times f(o, -m)$, which has been proved to be a quantity independent of the cosines. In this case, therefore, we shall have

$$f(o, m) \times f(o, -m) = \mathrm{B};$$

B being a quantity from which the cosines are eliminated, and which is now to be investigated.

If, in the foregoing case, we suppose $m' = n - m$ and $s = n$, we shall get

$$f(o, m) \times f(o, -m) = \Psi(o) + e^{m}\Psi(1) + e^{2m}\Psi(2) \ldots e^{(n-1)m}\Psi(n-1):$$

but here, because $e^{s} = e^{n} = 1$, e and its powers disappear from the expression of $\Psi(\mu)$, and we have

$$\Psi(\lambda) = \cos.\varphi\cos.a^{\lambda}\varphi + \cos.a\varphi\cos.a^{\lambda+1}\varphi + \cos.a^2\varphi \times \cos.a^{\lambda+2}\varphi +, \&c.;$$

and, by expanding the products of the cosines, as before,

$$\Psi(\lambda) = \frac{1}{2}\left\{\cos.w\varphi + \cos.a\,.\,w\varphi + \cos.a^2 w\varphi \ldots + \cos.a^{n-1}\,.\,w\varphi\right\} + \frac{1}{2}\left\{\cos.w'\varphi + \cos.a\,.\,w'\varphi + \cos.a^2\,.\,w'\varphi \ldots . + \cos.a^{n-1}\,.\,w'\varphi\right\}.$$

When $\lambda = 0$, $w = 2$, $w' = 0$; therefore

$$\Psi(o) = \frac{1}{2}.\left\{\cos.2\varphi + \cos.a\,.\,2\varphi + \cos.a^2\ 2\varphi \ldots + \cos.a^{n-1}\,.\,2\varphi\right\}$$

$$+\frac{1}{2}\left\{1+1+1+1+1\ldots\ldots\ldots+1\right\}.$$

But no alteration is made in equation (1) when we substitute, instead of the arc φ, any one of its multiples, or, which is the same thing, change φ into $a\varphi$, $a^2\varphi$, &c.; because such substitution or change continually reproduces the same cosines. Thus it appears that the sum of the n cosines in $\Psi(o)$ is equal to $-\frac{1}{2}$; and we have

$$\Psi(o)=\frac{n}{2}-\frac{1}{4}.$$

For every other value of λ, w and w' are neither of them equal to zero, nor to a multiple of n; wherefore, according to what has just been said, the sum of the n cosines in each of the two parts of $\Psi(\lambda)$ is equal to $-\frac{1}{2}$; and thus, when λ is not equal to zero, we have

$$\Psi(\lambda)=\frac{1}{2}\times-\frac{1}{2}+\frac{1}{2}\times-\frac{1}{2}=-\frac{1}{2}.$$

By substituting the values of $\Psi(o)$ and $\Psi(\lambda)$, we get

$$f(o,m)\times f(o,-m)=$$

$$\frac{n}{2}-\frac{1}{4}-\frac{1}{2}\left(e^{m}+e^{2m}+e^{3m}\ldots+e^{(n-1)m}\right).$$

But, as was already proved,

$$-1=e^{m}+e^{2m}+e^{3m}\ldots\ldots+e^{(n-1)m}:$$

wherefore

$$f(o,m)\times f(o,-m)=\frac{n}{2}-\frac{1}{4}+\frac{1}{2}=\frac{2n+1}{4}=\frac{1}{4}p.$$

Now, if we put $k^2=\frac{1}{4}p$, we have finally

$$f(o,m)\times f(o,-m)=k^2\ldots\ldots(3).$$

When n is an even number, it is obvious that $f\left(o,\frac{n}{2}\right)$ $=f\left(o,-\frac{n}{2}\right)$: therefore it follows as a corollary, that in this case

$$f\left(o,\frac{n}{2}\right)=f\left(o,-\frac{n}{2}\right)=\pm k=\pm\frac{1}{2}\sqrt{p}.$$

By applying the equation (2), first to the indices m and m', and then to the indices $n-m$ and $n-m'$, or to m and m' taken negatively, we deduce

$$f(o,m)\times f(o,m')=(m,s)\times f(o,s),$$
$$f(o,-m)\times f(o,-m')=(-m,-s)\times f(o,-s):$$

and by multiplying we shall get, on account of equation 3), this remarkable formula, viz.

$$(m,s)\times(-m,-s)=k^2\ldots(4).$$

By successive applications of the equation (2), we get

$$f(o,1)\times f(o,1)=(1,2)\times f(o,2),$$
$$f(o,1)\times f(o,2)=(1,3)\times f(o,3),$$
$$f(o,1)\times f(o,3)=(1,4)\times f(o,4),$$
&c.

By combining these equations, and writing P for $f(o,1)$, we deduce

$$P^2=(1,2)\,.f(o,2),$$
$$P^3=(1,2)\,.(1,3)\,.f(o,3),$$
$$P^4=(1,2)\,.(1,3)\,.(1,4)\,.f(o,4),$$
&c.

Wherefore, when n is an even number,

$$P^{\frac{n}{2}}=(1,2)\,.(1,3)\,.(1,4)\ldots\ldots\left(1,\frac{n}{2}\right).f\left(o,\frac{n}{2}\right);$$

and, by squaring and observing that, by equation (3), $\left\{f\left(o,\frac{n}{2}\right)\right\}^2=k^2$, we get

$$P^n=(1,2)^2.(1,3)^2.(1,4)^2\ldots\left(1,\frac{n}{2}\right)^2.k^2. \qquad (5).$$

When n is an odd number, we have, in like manner,

$$P^{\frac{n-1}{2}}=(1,2)\,.(1,3)\,.(1,4)\ldots\left(1,\frac{n-1}{2}\right)\times f\left(o,\frac{n-1}{2}\right),$$

$$P^{\frac{n+1}{2}}=(1,2)\,.(1,3)\,.(1,4)\ldots\left(1,\frac{n+1}{2}\right)\times f\left(o,\frac{n+1}{2}\right);$$

but, by equation (3), $f\left(o,\frac{n-1}{2}\right)\times f\left(o,\frac{n+1}{2}\right)=k^2$; wherefore

$$P^n=(1,2)^2.(1,3)^2.(1,4)^2\ldots\left(1,\frac{n-1}{2}\right)^2.\left(1,\frac{n+1}{2}\right).k^2\ldots(6).$$

Again, from the preceding expressions we get

$$f(o,2)=\frac{1}{(1,2)}.P^2;$$

and, by equation (4),

$$f(o,2)=\frac{(-1,-2)}{k^2}.P^2.$$

In like manner,

$$f(o,3)=\frac{(-1,-2)}{k^2}.\frac{(-1,-3)}{k^2}.P^3,$$

$$f(o,4)=\frac{(-1,-2)}{k^2}.\frac{(-1,-3)}{k^2}.\frac{(-1,-4)}{k^2}.P^4,$$
&c.

These formulæ need only be continued till we obtain the value of the function $f\left(o,\frac{n-2}{2}\right)$ when n is even, and of $f\left(o,\frac{n-1}{2}\right)$ when n is odd; the remaining functions $f(o,n-2)$, $f(o,n-3)$, &c. or, which is the same thing, $f(o,-2)$, $f(o-3)$, &c. being derived from the preceding values merely by changing the signs of the different indices of e. Thus, if we write P′ for $f(o,-1)$, we shall have

$$f(o,-2)=\frac{(1,2)}{k^2}.P'^2,$$

$$f(o,-3)=\frac{(1,2)}{k^2}.\frac{(1,3)}{k^2}.P'^3,$$

$$f(o,-4)=\frac{(1,2)}{k^2}.\frac{(1,3)}{k^2}.\frac{(1,4)}{k^2}.P'^4,$$
&c.

Now, ϱ being any number less than n, it has been shown that

$$o=1+e^{\varrho}+e^{2\varrho}+e^{3\varrho}\ldots\ldots+e^{(n-1\varrho)}:$$

and hence if we attend to the nature of functions $f(o,o)$, $f(o,1)$, $f(o,2)$, &c. we shall readily get

$$\cos.a^{\varrho}\varphi=$$

$$\frac{f(o,o)}{n}+\frac{1}{n}.\left\{e^{-\varrho}.f(o,1)+e^{-2\varrho}f(o,2)+e^{-3\varrho}f(o,3)+,\ \&c.\right\};$$

or, by arranging the terms differently, and because

$f(o, o) = -\frac{1}{2}$,

$$\cos. a^{\varrho}\varphi = -\frac{1}{2n} + \frac{1}{n}.\left\{e^{-\varrho} f(o, 1) + e^{\varrho}.f(o, -1)\right\}$$
$$+\frac{1}{n}.\left\{e^{-2\varrho}.f(o, 2) + e^{2\varrho}.f(o, -2)\right\}$$
$$+\frac{1}{n}.\left\{e^{-3\varrho}.f(o, 3) + e^{3\varrho}.f(o, -3)\right\}$$
&c.

and it is to be observed that, when n is even, the last term is the single quantity $\frac{1}{n}\times e^{-\frac{n}{2}\varrho}\times f\left(o, \frac{n}{2}\right)$, which has no corresponding part. Now, this quantity is entirely known. For, since $e^n = 1$, we have $e^{\frac{n}{2}} = e^{-\frac{n}{2}} = \pm 1$; but e has been so assumed, that none of its powers with indices less than n are equal to unit; and, therefore,

$e^{-\frac{n}{2}} = -1$, and $e^{-\frac{n}{2}\varrho} = (-1)^{\varrho}$. Again, by equation (3), $f\left(o, \frac{n}{2}\right) = \pm k$; wherefore we have

$$\frac{1}{n}.e^{-\frac{n}{2}\varrho}.f\left(o, \frac{n}{2}\right) = \frac{1}{n}.(-1)^{\varrho}.\times \pm k.$$

On the whole, the preceding analysis brings us to the following formulæ, which contain the solution of the problem, viz.

when n is even, by equation (5),

$$P^{\frac{n}{2}} = (1, 2).(1, 3).(1, 4)....\left(1, \frac{n}{2}\right)\times \pm k;$$

when n is odd, by equation (6),

$$P^n = (1, 2)^2.(1, 3)^2(1, 4)^2...\left(1, \frac{n-1}{2}\right)^2.\left(1, \frac{n+1}{2}\right).k^2;$$

and by equation (2), $PP' = k^2$.

Finally, by substituting the values of $f(o, 2)$, $f(o, 3)$, &c. $f(o, -2)$, $f(o, -3)$, &c. in the expression of $\cos. a^{\varrho}\varphi$, we get

$$\cos. a^{\varrho}\varphi = -\frac{1}{2n} + \frac{k}{n}.\left\{\frac{e^{-\varrho}P}{k} + \frac{e^{\varrho}P'}{k}\right\}$$
$$+\frac{k}{n}.\left\{\frac{(-1, -2)}{k}.\left(\frac{e^{-\varrho}P}{k}\right)^2 + \frac{(1, 2)}{k}.\left(\frac{e^{\varrho}P'}{k}\right)^2\right\}$$
$$+\frac{k}{n}.\left\{\frac{(-1, -2)}{k}.\frac{(-1, -3)}{k}.\left(\frac{e^{-\varrho}P}{k}\right)^3 + \frac{(1, 2)}{k}.\frac{(1, 3)}{k}\left(\frac{e^{\varrho}P'}{k}\right)^3\right\}$$
$+$, &c.

the series of terms must be continued till the last index of $\frac{e^{-\varrho}P}{k}$ and $\frac{e^{\varrho}P'}{k}$ is $\frac{n-1}{2}$ when n is odd, and $\frac{n-2}{2}$ when n is even; and, in this last case, the quantity $\frac{1}{n}\times(-1)^{\varrho}\times \pm k$, must be added, prefixing to k the same sign that is given to it in the value of $P^{\frac{n}{2}}$.

The solution of the problem is thus reduced to the computation of the functions (1, 2), (1, 3), &c. which requires no more than the substitution of 1 for m, and of 2, 3, 4, &c. successively for s, in the expression of A, equation (2). The half of these functions that have negative indices are deduced from the other half, merely by changing the signs of the several indices of e, or by means of equation (4). All the cosines sought are found by substituting o, 1, 2, 3, &c. successively for ϱ. Although the function P is susceptible of n different values, represented by x, ex, e^2x, &c.; yet the same cosines are deduced from any one of these values. By this means all ambiguity is avoided with regard to the system of values that represent the cosines; but the numerical value that must be attached to each particular cosine remains quite indeterminate, because φ may equally stand for $\frac{360°}{p}$, $2\times\frac{360°}{p}$, $3\times\frac{360°}{p}$, &c. The adaptation of the numerical quantities to the geometrical cosines must be made out by means of their relative magnitudes; the largest number answering to the greatest cosine. But when the value of one cosine is fixed, the rest are unambiguously determined by means of their indices.

In the formula for $\cos. a^{\varrho}\varphi$ all the terms in which two quantities are combined have real values, although their forms are imaginary. But it is not difficult to transform them into equivalent quantities without the imaginary sign.

It is manifest that the functions (1, 2) and (— 1, — 2) are of this form, viz.

$$(1, 2) = A + Be + Ce^2 + De^3 .. + Ne^{n-1},$$
$$(-1, -2) = A + Be^{-1} + Ce^{-2} + De^{-3}... + Ne^{-(n-1)},$$

A, B, C, &c. denoting given co-efficients.

But we have generally

$$e^{\lambda} = \cos. \lambda r + \sin. \lambda r\sqrt{-1},$$
$$e^{-\lambda} = \cos. \lambda r - \sin. \lambda r\sqrt{-1}:$$

wherefore, by combining the two expressions of (1, 2) and (— 1, — 2), we shall readily get

$$\frac{(1, 2) + (-1, -2)}{2} = A + B\cos. r + C\cos. 2r +, \&c.$$
$$\frac{(1, 2) - (-1, -2)}{2} = \quad B\sin. r + C\sin. 2r +, \&c.$$

But, on account of equation (4), we may assume

$$(1, 2) = k(\cos. \beta + \sin. \beta\sqrt{-1}),$$
$$(-1, -2) = k(\cos. \beta - \sin. \beta\sqrt{-1});$$

and, by substituting these values in the last expressions, we get

$$k\cos. \beta = A + B\cos. r + C\cos. 2r +, \&c.$$
$$k\sin. \beta = \quad B\sin. r + C\sin. 2r +, \&c.$$

by which means the arc β is determined without ambiguity, since both its sine and cosine are ascertained. In like manner are determined the several arcs in the formulæ

$$(1, 3) = k(\cos. \beta' + \sin. \beta'\sqrt{-1}),$$
$$(-1, -3) = k(\cos. \beta' - \sin. \beta'\sqrt{-1}),$$
$$(1, 4) = k(\cos. \beta'' + \sin. \beta''\sqrt{-1}),$$
$$(-1, -4) = k(\cos. \beta'' - \sin. \beta''\sqrt{-1}),$$
&c.

Again, because $PP' = k^2$, we may assume

$$P = k(\cos. w + \sin. w\sqrt{-1}),$$
$$P' - k(\cos. w - \sin. w\sqrt{-1}),$$

And if these values, and the similar values of the functions (1, 2), (1, 3), &c. be substituted in the value of $P^{\frac{n}{2}}$, we shall readily deduce, when n is an even number,

$$\frac{n}{2}\cdot w = \beta + \beta' + \beta'' +, \text{\&c.}$$

When n is an odd number, we must separate the function $\left(1, \frac{n+1}{2}\right)$ from the rest, by supposing $\left(1, \frac{n+1}{2}\right) = k$ $(\cos.\gamma + \sin.\gamma\sqrt{-1})$:
and then, by means of equation (6), we shall easily obtain

$$nw = 2(\beta + \beta' + \beta'' +, \text{\&c.}) + \gamma.$$

The two last formulæ determine the arc w; and we likewise have

$$\frac{e^{-\varrho}P}{k} = \cos.(w - \varrho\tau) + \sin.(w - \varrho\tau)\sqrt{-1},$$

$$\frac{e^{\varrho}P'}{k} = \cos.(w - \varrho\tau) - \sin.(w - \varrho\tau)\sqrt{-1};$$

and, by putting $w^{(\varrho)} = w - \varrho\tau$,

$$\frac{e^{-\varrho}P}{k} = \cos.w^{(\varrho)} + \sin.w^{(\varrho)}\sqrt{-1},$$

$$\frac{e^{\varrho}P}{k} = \cos.w^{(\varrho)} - \sin.w^{(\varrho)}\sqrt{-1}.$$

Finally, by substituting the different values exhibited above in the formula for $\cos.a^{\varrho}\phi$, we shall get

$$\begin{aligned}\cos.a^{\varrho}\phi = -\frac{1}{2n} &+ \frac{2k}{n}.\cos.w^{(\varrho)} \\ &+ \frac{2k}{n}.\cos.(2w^{\varrho} - \beta) \\ &+ \frac{2k}{n}.\cos.(3w^{(\varrho)} - \beta - \beta') \\ &+ \frac{2k}{n}.\cos.(4w^{(\varrho)} - \beta - \beta' - \beta'') \\ &\text{\&c.}\end{aligned}$$

the series of terms being continued till all the arcs β, β', β'', &c. are taken in when n is odd; and till they are all taken in except the last when n is even, in which case also the quantity $(-1)^{\varrho}.\frac{k}{n}$ must be added.

By the preceding analysis the division of the circle into p equal parts is accomplished, when p is a prime number, by dividing a given arc into n or $\frac{p-1}{2}$ equal parts. And this conclusion agrees with the general proposition of M. Gauss. For the nth part of a given arc is found by bisecting as often as n is divisible by 2, trisecting as often as it is divisible by 3, and so on. When n is a power of two, as in the case of the polygon of 17 sides, the solution is effected by repeated bisections, and thus comes under the elementary geometry. Supposing the division of the circle to be accomplished, we must further resolve the quadratic equation

$$x + \frac{1}{x} = 2\cos..\frac{\lambda \times 360°}{p},$$

in order to find the roots of the binomial equation $x^p - 1 = 0$.

The following examples are subjoined for the sake of illustrating the method of calculation. And, in the first place, we may take the case of $p = 11$ equivalent to finding the roots of the equation $x^{11} - 1 = 0$, which was first solved by Vandermonde, and has been considered both by Lagrange and Legendre. Here, $n = 5$; $k = \frac{1}{2}\sqrt{11}$;
$\tau = \frac{360°}{5} = 72°$ $= \cos.\tau + \sin.\tau\sqrt{-1}$; and, as 2 is a primitive root of 11, we may suppose $a = 2$. In order to find the numbers $h(\lambda)$ and $h'(\lambda)$, write down the series 1, 2, 3, &c. as far as n or 5; and, above each number, write the power of a equal to it when the multiples of 11 are rejected, taking always the least remainder, whether positive or negative: thus,

$$\begin{array}{ccccc} a^0 & a^1 & a^3 & a^2 & a^4 \\ 1 & 2 & 3 & 4 & 5. \end{array}$$

In this arrangement of the powers of a, it is evident that, λ denoting any index, $h(\lambda)$ is the next on the right hand, and $h'(\lambda)$ the next on the left hand: we have, therefore,

$$\begin{array}{cc} \multicolumn{2}{c}{i = 1,} \\ h(1) = 3, & h'(1) = 0, \\ h(2) = 4, & h'(2) = 3, \\ h(3) = 2, & h'(3) = 1, \\ h(4) = 4, & h'(4) = 2. \end{array}$$

Now, substitute these numbers in the expression of A, equation (2), and likewise put $m = 1$; then

$$\begin{aligned}A = \frac{1}{2}e^{-s} &+ \frac{1}{2}e^{1-3s} + \frac{1}{2}e \\ &+ \frac{1}{2}e^{2-4s} + \frac{1}{2}e^{2-3s} \\ &+ \frac{1}{2}e^{3-2s} + \frac{1}{2}e^{3-s} \\ &+ \frac{1}{2}e^{4-4s} + \frac{1}{2}e^{4-2s}.\end{aligned}$$

In order to find (1, 2) and (1, 3), we have only to substitute 2 and 3 for s in the expression of A; hence

$$(1, 2) = 1 + 2e + \frac{1}{2}e^3 + e^4,$$

$$(1, 3) = 1 + \frac{1}{2}e + 2e^2 + e^3;$$

which values will, in this case, be rendered somewhat more simple by combining them with the equation $0 = 1 + e + e^2 + e^3 + e^4$: and thus we get

$$(1, 2) = e - e^2 - \frac{1}{2}e^3 = m,$$

$$(1, 3) = e^2 - e^4 - \frac{1}{2}e = \mu.$$

The functions $(-1, -2)$ and $(-1, -3)$ are found by subtracting the indices of e in the values of (1, 2) and (1, 3) from 5, which is equivalent to changing the signs of the indices; therefore

$$(-1, -2) = e^4 - e^3 - \frac{1}{2}e^2 = m,$$

$$(-1, -3) = e^3 - e - \frac{1}{2}e^4 = \mu'.$$

And it will be found, by actually multiplying, that

$$mm' = k^2 = \frac{11}{4} \text{ and } \mu\mu' = k^2 = \frac{11}{4}.$$

These values being found, we have, according to the foregoing method,

$$P^5 = (1, 2)^2 \cdot (1, 3) \cdot k^2 = m^2\mu \cdot k^2,$$

$$P'^5 = \frac{k^{10}}{P^5} = (-1, -2)^2.(-1, -3).k^2 = m'^2\mu'.k^2;$$

and hence $\frac{P}{k} = \frac{1}{k}(m^2\mu.k^2)^{\frac{1}{5}}$,

$$\frac{P'}{k} = \frac{1}{k}(m'^2\mu'.k^2)^{\frac{1}{5}},$$

$$\frac{m'}{k}\cdot\frac{P^2}{k^2} = \frac{1}{k}(m'\mu^2.k^2)^{\frac{1}{5}}$$

$$\frac{m}{k}\cdot\frac{P'^2}{k^2} = \frac{1}{k}(m\mu'^2.k^2)^{\frac{1}{5}}$$

wherefore we have

$$\cos. a^{\varrho}\phi = -\frac{1}{10} + \frac{e^{-\varrho}}{5}\cdot(m^2\mu\cdot k^2)^{\frac{1}{5}} + \frac{e^{\varrho}}{5}\cdot(m'^2\mu'\cdot k^2)^{\frac{1}{5}}$$
$$+\frac{e^{-2\varrho}}{5}\cdot(m'\mu^2\cdot k^2)^{\frac{1}{5}} + \frac{e^{2\varrho}}{5}\cdot(m\mu'^2\cdot k^2)^{\frac{1}{5}}.$$

If, in this expression, we make $\varrho=0$, and substitute the numerical values of k^2, and of e and its powers, in the quantities under the radical sign, the result will coincide with the formula of Vandermonde, and with the calculation of Lagrange.

The expression just found being imaginary, if it be required to reduce it to a form fit for calculation, we must begin with substituting the values of e and its powers in m and μ: then

$$m=(\cos.\tau-\cos.2\tau-\frac{1}{2}\cos.3\tau)$$
$$+(\sin.\tau-\sin.2\tau-\frac{1}{2}\sin.3\tau)\cdot\sqrt{-1},$$
$$\mu=(\cos.2\tau-\cos.4\tau-\frac{1}{2}\cos.\tau)$$
$$+(\sin.2\tau-\sin.4\tau-\frac{1}{2}\sin.\tau)\cdot\sqrt{-1}.$$

Now, $\cos.\tau=\cos.4\tau=-\frac{1}{4}+\frac{1}{4}\sqrt{5}$, and $\cos.2\tau=\cos.3\tau=-\frac{1}{4}-\frac{1}{4}\sqrt{5}$; also $\sin.\tau=-\sin.4\tau$, and $\sin.2\tau=-\sin.3\tau$: wherefore

$$m=(\cos.\tau-\frac{3}{2}\cos.2\tau)+(\sin.\tau-\frac{1}{2}\sin.2\tau)\cdot\sqrt{-1},$$
$$\mu=(\cos.2\tau-\frac{3}{2}\cos.\tau)+(\sin.2\tau+\frac{1}{2}\sin.\tau)\cdot\sqrt{-1}.$$

Again,

$$m=k(\cos.\beta+\sin.\beta\cdot\sqrt{-1}),$$
$$\mu=k(\cos.\gamma+\sin.\gamma\sqrt{-1});$$

consequently

$$\cos.\beta=\frac{1}{k}(\cos.\tau-\frac{3}{2}\cos.2\tau)=\frac{1+5\sqrt{5}}{4\sqrt{11}},$$
$$\sin.\beta=\frac{1}{k}(\sin.\tau-\frac{1}{2}\sin.2\tau),$$
$$\cos.\gamma=\frac{1}{k}(\cos.2\tau-\frac{3}{2}\cos.\tau)=\frac{-1+5\sqrt{5}}{4\sqrt{11}},$$
$$\sin.\gamma=\frac{1}{k}(\sin.2\tau+\frac{1}{2}\sin.\tau).$$

Hence

$$\beta=23^\circ\ 20'\ 46'',$$
$$\gamma=140\ \ 7\ \ 6\tfrac{1}{2},$$
$$5\omega=2\beta+\gamma=186\ \ 48\ \ 38\tfrac{1}{2},$$
$$\omega=37\ \ 21\ \ 44,$$
$$\omega^{(\varrho)}=\omega-\varrho\times72^\circ:$$
$$\cos.a^{\varrho}\phi=-\frac{1}{10}+\frac{\sqrt{11}}{5}\cdot\left\{\cos.\omega^{(\varrho)}+\cos.(2\omega^{\varrho}-\beta)\right\}.$$

By making ϱ successively equal to 0, 1, 2, 3, 4, the formula will give all the ten cosines of a polygon of eleven sides inscribed in a circle; because $\cos.\frac{360^\circ}{11}=\cos.10\cdot\frac{360^\circ}{11}$, $\cos.2\cdot\frac{360^\circ}{11}=\cos.9\cdot\frac{360^\circ}{11}$, &c. It determines also the order of the arcs to which the numerical quantities belong; so that when the value of one cosine is fixed, the values of all the rest are likewise ascertained.

This last formula coincides with the calculation of Legendre.

The next example shall be the case of $p=17$. Then, $n=8$, $k=\frac{1}{2}\sqrt{17}$, $\tau=\frac{360^\circ}{8}=45^\circ$, and $e=\cos.\tau+\sin.\tau\sqrt{-1}$; and, 3 being one of the primitive roots of 17, we may take $a=3$. Now, arranging the powers of a as in the last example, we have

$$a^0,\ a^6,\ a^1\ a^4,\ a^5,\ a^7,\ a^3,\ a^2$$
$$1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7,\ 8:$$

and hence,

$$i=6$$

$h(1)=4,$	$h'(1)=6,$
$h(2)=2,$	$h'(2)=3,$
$h(3)=2,$	$h'(3)=7,$
$h(4)=5,$	$h'(4)=1,$
$h(5)=7,$	$h'(5)=4,$
$h(6)=1,$	$h'(6)=0,$
$h(7)=3,$	$h'(7)=5.$

By substituting these numbers in the expression of A, and likewise by putting $m=1$, we get

$$\mathrm{A}=\frac{1}{2}e^{-6s}+\frac{1}{2}e^{1-4s}+\frac{1}{2}e^{1-6s}$$
$$+\frac{1}{2}e^{2-2s}+\frac{1}{2}e^{2-3s}$$
$$+\frac{1}{2}e^{3-2s}+\frac{1}{2}e^{3-7s}$$
$$+\frac{1}{2}e^{4-5s}+\frac{1}{2}e^{4-s}$$
$$+\frac{1}{2}e^{5-7s}+\frac{1}{2}e^{5-4s}$$
$$+\frac{1}{2}e^{6-s}+\frac{1}{2}e^{6}$$
$$+\frac{1}{2}e^{7-3s}+\frac{1}{2}e^{7-5s}.$$

In order to have the functions (1, 2), (1, 3), (1, 4), nothing more is necessary than to substitute 2, 3, 4 for s in the expression of A: then, observing that $e+e^5=0$, $e^2+e^6=0$, $e^3+e^7=0$, we readily get

$$(1,2)=\frac{3}{2}e^4+e^7+e^5=-\frac{3}{2}-\sqrt{-2}=-m,$$
$$(1,3)=1+\frac{1}{2}e^4+2e^6=\frac{1}{2}-2\sqrt{-1}=n,$$
$$(1,4)=\frac{3}{2}+e+e^3=\frac{3}{2}+\sqrt{-2}=m:$$

and hence

$$(-1,-2)=\frac{3}{2}e^4+e+e^3=-\frac{3}{2}+\sqrt{-2}=-m',$$
$$(-1,-3)=1+\frac{1}{2}e^4+2e^2=\frac{1}{2}+2\sqrt{-1}=n',$$
$$(-1,-4)=\frac{3}{2}+e^7+e^5=\frac{3}{2}-\sqrt{-2}=m'.$$

These values being found, we next have

$$\mathrm{P}^4=(1,2)\cdot(1,3)\cdot(1,4)\cdot f(0,4);$$
$$f(0,4)=\pm k;$$

therefore, making $f(0,4)=-k$,

$$\mathrm{P}^4=m^2nk,$$
$$\mathrm{P}'^4=\frac{k^8}{\mathrm{P}^4}=m'^2n'k;$$

and hence

$$\frac{1}{k}\mathrm{P}=\frac{1}{k}(m^2nk)^{\frac{1}{4}};\ \frac{1}{k}\cdot\mathrm{P}'=\frac{1}{k}(m'^2n'k)^{\frac{1}{4}};$$

$$-\frac{m'}{k}\cdot\frac{P^2}{k^2}=-\frac{1}{k}\cdot\sqrt{nk}\,;\ -\frac{m}{k}\cdot\frac{P^2}{k^2}=-\frac{1}{k}\sqrt{n'k}\,;$$

$$-\frac{m'}{k}\cdot\frac{n'P^3}{kk^3}\cdot=-\frac{1}{k}(m^2n'k)^{\frac{1}{4}}\,;\ -\frac{m}{k}\cdot\frac{n}{k}\cdot\frac{P'^3}{k^3}$$

$$=-\frac{1}{k}(m'^2nk)^{\frac{1}{4}}\,;$$

$$\cos.\ a^{\varrho}\varphi=-\frac{1}{16}-(-1)^{\varrho}\cdot\frac{\sqrt{17}}{16}$$

$$+\frac{1}{8}\cdot\left\{e^{-\varrho}(m^2nk)^{\frac{1}{4}}+e^{\varrho}(m'^2n'k)^{\frac{1}{4}}\right\}$$

$$-\frac{1}{8}\cdot\left\{e^{-2\varrho}(nk)^{\frac{1}{2}}+e^{2\varrho}(n'k)^{\frac{1}{2}}\right\}$$

$$-\frac{1}{8}\left\{e^{-3\varrho}(m^2n'k)^{\frac{1}{4}}+e^{3\varrho}(m'^2nk)^{\frac{1}{4}}\right\}.$$

In order to reduce this expression, we shall put

$$\varphi(\varrho)=e^{-2\varrho}\sqrt{nk}+e^{2\varrho}\sqrt{n'k},$$

$$\Psi(\varrho)=e^{-\varrho}(m^2nk)^{\frac{1}{4}}+e^{\varrho}(m'^2n'k)^{\frac{1}{4}}$$

$$-e^{-3\varrho}(m^2n'k)^{\frac{1}{4}}-e^{3\varrho}(m'^2nk)^{\frac{1}{4}}.$$

And because $e^4=e^{-4}=-1$, we get $e^{6\varrho}=e^{-2\varrho}=(-1)^{\varrho}\cdot e^{2\varrho}$, and $e^{-6\varrho}=e^{2\varrho}=(-1)^{\varrho}\cdot e^{-2\varrho}$. Wherefore, by squaring,

$$\left\{\varphi(\varrho)\right\}^2=2k^2+(-1)^{\varrho}\cdot k,$$

$$\left\{\Psi(\varrho)\right\}^2=4k^2-6k(-1)^{\varrho}+3\varphi(\varrho)-2k\cdot\varphi(\varrho)\cdot(-1)^{\varrho}.$$

Now, in the formula for cos. $a^{\varrho}\varphi$, viz. cos. $a^{\varrho}\varphi=-\frac{1}{16}-(-1)^{\varrho}\cdot\frac{\sqrt{17}}{16}-\frac{1}{8}\varphi(\varrho)-\frac{1}{8}\Psi(\varrho)$, if we change ϱ into $\varrho+4$, no alteration will be produced, except that $\Psi(\varrho)$ will change its sign; for it is obvious that

$$\Psi(\varrho+4)=e^4\cdot\Psi(\varrho)=-\Psi(\varrho).$$

Hence we readily deduce these two equations, viz.

$$\frac{1}{2}(\cos.\ a^{\varrho}\varphi+\cos.\ a^{\varrho+4}\varphi)=-\frac{1}{16}-(-1)^{\varrho}\cdot\frac{\sqrt{17}}{16}-\frac{1}{8}\varphi(\varrho),$$

$$\frac{1}{4}(\cos.\ a^{\varrho}\varphi-\cos.\ a^{\varrho+4}\varphi)^2=\frac{1}{64}\times\left\{\Psi(\varrho)\right\}^2.$$

If we suppose $\varrho=0$, then

$$\left\{\varphi(0)\right\}^2=2k^2+k;$$

wherefore

$$\frac{1}{2}(\cos.\ \varphi+\cos.\ a^4\varphi)=-\frac{1}{16}-\frac{\sqrt{17}}{16}-\frac{1}{8}\sqrt{2k^2+k},$$

$$\frac{1}{4}(\cos.\ \varphi-\cos.\ a^4\varphi)^2=\frac{1}{64}\cdot\left\{4k^2-6k-(2k-3)\times\sqrt{2k^2+k}\right\}.$$

And, when $\varrho=2$, then

$$\varphi(2)=e^4\cdot\varphi(0)=-\varphi(0);$$

wherefore

$$\frac{1}{2}(\cos.\ a^2\varphi+\cos.\ a^6\varphi)=-\frac{1}{16}-\frac{\sqrt{17}}{16}+\frac{1}{8}\sqrt{2k^2+k},$$

$$\frac{1}{4}(\cos.\ a^2-\cos.\ a^6\varphi)^2=\frac{1}{64}\cdot\left\{4k^2-6k+(2k-3)\times\sqrt{2k^2+k}\right\}$$

Next, suppose $\varrho=1$, then

$$\left\{\varphi(1)\right\}^2=2k$$

wherefore

$$\frac{1}{2}(\cos.\ a\varphi+\cos.\ a^5\varphi)=-\frac{1}{16}+\frac{\sqrt{17}}{16}+\frac{1}{8}\sqrt{2k^2-k},$$

$$\frac{1}{4}(\cos.\ a\varphi-\cos.\ a^5\varphi)^2=\frac{1}{64}\cdot\left\{4k^2+6k+(2k+3)\sqrt{2k^2-k}\right\}:$$

and, finally, making $\varrho=3$, we get

$$\varphi(3)=e^4\times\varphi(1)=-\varphi(1);$$

wherefore

$$\frac{1}{2}(\cos.\ a^3\varphi+\cos.\ a^7\varphi)=-\frac{1}{16}+\frac{\sqrt{17}}{16}-\frac{1}{8}\sqrt{2k^2-k},$$

$$\frac{1}{4}(\cos.\ a^3\varphi-\cos.\ a^7\varphi)^2+\frac{1}{64}\cdot\left\{4k^2+6k-(2k+3)\sqrt{2k^2-k}\right\}.$$

These formulæ enable us to find the numerical values of all the cosines sought; observing always that φ is indeterminate, and varies with the primitive root from which the solution is deduced. (J. I.)

EQUATOR (*æquare, to make equal*), in *Astronomy* and *Geography*, a great circle of the sphere, equally distant from the two poles of the world, or having the same poles as the world. It is called *equator* because when the sun is in it the days and nights are *equal;* whence also it is denominated the *equinoctial*; and when drawn on maps, planispheres, or globes, it is called the *equinoctial line*, or simply *the line.* Every point in the equator is 90 degrees or a quadrant's distance from the poles of the world; and hence the equator divides the sphere into two equal hemispheres, in one of which is the northern, and in the other the southern pole. See Astronomy.

EQUATORIAL, pertaining to the equator.

Equatorial, an astronomical instrument for directing a telescope at once to any celestial object whose right ascension and declination are known, and for keeping the object in view for any length of time notwithstanding the diurnal motion. See Astronomy, vol. iv., p. 53.

EQUERRY (Fr. *écurie, a stable*), an officer who has the care and management of the horses of a king or prince.

The equerries of the royal household in England are certain officers under the Master of the Horse, the first of whom is styled chief equerry and clerk-marshal, and has a salary of L.500 a-year. The royal equerries in rotation attend the sovereign when riding abroad in state. Other members of the royal family are likewise attended by equerries.

EQUES Auratus, a knight-bachelor; styled *auratus* because anciently knights alone had the privilege of adorning their armour with gold. In law its equivalent term is *miles* or *chevalier.*

EQUESTRIAN (Lat. *eques, a horseman*, from *equus, a horse*), pertaining to horses or to horsemanship.

EQUIANGULAR, having equal angles; as a square, an equilateral triangle, &c.

EQUIDISTANT, being at an equal distance from some fixed point or place.

EQUILATERAL, having all the sides equal; as an equilateral triangle, a square, &c.

EQUILIBRIUM (Lat.), equipoise, equality of weight, balance; as when the two ends of a lever or a balance,

charged with an equal weight, maintain an even or level position, parallel to the horizon. See MECHANICS.

EQUIMULTIPLE, in *Arithmetic* and *Geometry*, a number or quantity multiplied by the same number or quantity. Hence equimultiples are always in the same ratio to each other as the simple quantities before multiplication. Thus, if 6 and 8 are multiplied by 4, the equimultiples 24 and 32 will be to each other as 6 to 8.

EQUINOCTIAL (*æquus, equal*, and *nox, night*), in *Astronomy*, a great circle of the sphere, under which the equator moves in its diurnal motion.

The equinoctial, or æquinoctial line, is ordinarily confounded with the equator; but there is a difference, the equator being moveable, and the equinoctial immoveable; the equator being drawn about the convex surface of the sphere, and the equinoctial on the concave surface of the *magnus orbis*.

When the sun, in its progress through the ecliptic, comes to this circle, the days and nights are equal all over the globe. The equinoctial, then, is the circle which the sun describes, or appears to describe, at the time of the equinoxes; that is, when the length of the day is everywhere equal to that of the night, which happens twice a-year, viz., about the 21st of March and the 23d of September.

EQUINOCTIAL *Points*, the two points in which the equator and ecliptic intersect each other. The one, being in the first point of Aries, is called the *vernal point* or *equinox;* the other, in the first point of Libra, is denominated the *autumnal point* or *equinox*. See ASTRONOMY, vol. iv., p. 12.

EQUINOCTIAL *Dial*, a dial of which the plane is parallel to that of the equinoctial.

EQUINOX, in *Astronomy*, the time when the sun enters one of the equinoctial points.

The equinoxes happen when the sun is in the equinoctial circle, and the days are equal to the nights throughout the world, which is the case twice a-year; namely, about the 21st of March and the 23d of September, the former being called the vernal and the latter the autumnal equinox. See ASTRONOMY, vol. iv., p. 14; and PRECESSION OF THE EQUINOXES.

EQUIPOLLENCE (*æquus, equal*, and *pollens*, part. of *pollere, to be powerful*), in *Logic*, an equivalence between two or more propositions; that is, when they signify the same thing though differently expressed. Such terms or propositions are said to be *equipollent*.

EQUIRIA, in *Antiquity*, a festival said to have been instituted by Romulus, and celebrated with horse-races in the Campus Martius on the 27th of February, in honour of Mars.

EQUITES, an order of men in the commonwealth of Rome, to which we can furnish no exact parallel in modern times. They seem, indeed, to have resembled in some degree the gentry of England; with this difference, however, that they enjoyed peculiar privileges, and were more of a separate caste than any body of men which can now be pointed out. Their origin goes back to the earliest times of Roman history, though we can perceive, even from the legendary statements of Livy and Dionysius, that their constitution and mode of selection had been changed in the course of ages. During the reign of the kings they evidently appear to have been of noble birth, the younger branches of patrician families. This we may infer from the statement of Polybius (vi. 20), when he says that the knights *now* are chosen according to fortune; evidently intimating that their selection had depended on a different principle at a previous period. Romulus is said to have divided them into three centuries; and the very names of Ramnenses, Titienses, and Luceres, by which he designated them, point out distinctly their high origin. Both Tullus Hostilius and Tarquinius added to their number; but it was Servius Tullius (576 B.C.) who first organized them into a distinct body, and compelled the state to contribute annually to their maintenance. It is difficult to perceive in what way we are to explain the statement of Livy (i. 43), that the sum of ten thousand pounds of brass was given to each for the purchase of a horse; an enormous sum when compared with that at which oxen and sheep were rated in the table of penalties. They were bound, of course, to be provided with a noble steed, and may have been obliged to replace it if lost through any casualty in war. Its accoutrements, too, and a slave to take charge of it, were possibly all included in this large sum. But whether, when the censor ordered the knight to sell his horse, it was the intention that the outfit money should be refunded to the state, we have now no means of determining. Livy tells us also that a tax of two thousand pounds of brass was imposed on each *vidua*, to maintain a knight's horse. This certainly sounds very strange, for it seems inconceivable that there should have been such a large number of rich widows; and even though we understand by the word *vidua* every single woman, maiden as well as widow, we do not think that we thereby get out of the difficulty.

As early as 400 B.C. we find that a certain fortune was required to enable a man to be raised to the rank of eques. In that year, at the siege of Veii, we are told that those who possessed the requisite fortune, but to whom horses had not been assigned, offered to provide these at their own expense. This proposal was accepted; and then it was, according to Livy (v. 7), that they first received regular pay. In 303 B.C. the censors Q. Fabius and P. Decius established a law by which it was ordained that every fifth year a procession of the equites should take place, and that those who had misconducted themselves should be degraded from their rank. They now evidently became a very powerful body in the state; yet in 186 B.C. we find it allowed as a reward to P. Æbutius, that the censor should not assign him a public horse, and thereby compel him to serve as an eques against his will. This proves that the duties must have been burdensome, and regarded by many with distaste. In the later times of the republic they increased in power and consequence, when the judicial functions were transferred from the senate to the body of equites by the Sempronian law, passed by C. Gracchus about 123 B.C.; and a short time afterwards they became the farmers of the public revenues, by which they were enabled to amass immense riches. They were deprived of their judicial powers by Sylla; but they now possessed too much influence in the state to be excluded from the higher and more dignified offices. After his death they were admitted to their former power, which, however, they shared with the senate.

Towards the end of the republic, and under the emperors, the fortune requisite for an eques seems to have been four hundred sestertia, equal to about L.3229 of our money; and even at this time knights' horses were furnished by the state, as we find by ancient inscriptions of that period. (Gruter. *Inscrip.* 404.)

EQUITY (*æquitas*), even-handed justice; right; the impartial distribution of justice; the treating of others according to reason and justice, or in that way to which, by the natural law, that is, in strict justice, they are entitled.

Equity or justice is personified as a female divinity, bearing in one hand a sword, and in the other a balance.

In *Jurisprudence*, equity is defined by Grotius to be "the correction of that wherein the law (by reason of its generality) is deficient." "Equity," says Blackstone, "in its true and genuine meaning, is the soul and spirit of all law; positive law is construed, and rational law is made by it. In this respect equity is synonymous with justice; in that, to the true and sound interpretation of the rule."

Courts of Equity are distinguished from Courts of Law, in that the former have jurisdiction in cases where the proper remedy cannot be found, or cannot be administered to

the full extent of the relative rights of all parties in the courts of common law, in which proceedings can be carried on and decisions given only according to certain prescribed forms. The rights secured by the former are termed *legal;* those by the latter, *equitable.* Though equity, if not in name, at least in substance, must have a place in every rational system of jurisprudence, yet it is impossible that any code, however minute and particular, should embrace or provide for the infinite variety of human affairs, or should furnish rules applicable to every case.

The most general description of a court of equity is, that it has jurisdiction in cases where a plain, adequate, and complete remedy cannot be had in the common law courts. It is not confined or limited in its modes of relief, like courts of law, but grants relief to all parties in cases where they have rights *ex æquo et bono,* and modifies and fashions that relief according to circumstances. The jurisdiction of a court of equity is sometimes concurrent with that of courts of law, and sometimes it is exclusive. The most common exercise of concurrent jurisdiction is in cases of accident, fraud, mistake, &c. In many cases falling under these heads courts of law cannot afford redress; in others they can, though not always in so adequate a manner. It exercises exclusive jurisdiction in all cases of merely equitable rights, that is, such as are not recognized in courts of law. Most cases of trust and confidence come under this head. (See Justice Story's *Commentaries on Equity Jurisprudence;* Fonblanque *On Equity;* Maddock's *Treatise on Equity;* Lord Redesdale's *Treatise on Equity Pleadings.*)

The equity judges are the Lord Chancellor, the Master of the Rolls, the two Lords Justices of the Court of Appeal in Chancery, and the three Vice-Chancellors. The Lord Chancellor is a political officer of the highest importance and influence. He is a privy-councillor, and at the head of the judges and of the law. His duration of office, however, is dependent upon that of the ministry of which he is a member. The Master of the Rolls holds his appointment for life; and the Vice-Chancellors and Lords Justices of Appeal, by act 13th Will. III., cap. 2, during good conduct.

The salary of the Lord Chancellor is L.10,000; that of the Master of the Rolls and the Lords Justices of Appeal, L.6000 each; and that of the Vice-Chancellors, L.5000.

EQUIVALENT, equal in value, force, or effect, to something else.

Chemical Equivalents. See Chemistry, § *Combination of Definite Proportions,* vol. vi., p. 441.

EQUULEUS, or Eculeus (dim. of *equus, a horse*), in *Antiquity,* an instrument of torture used for extorting confession from slaves and criminals. (See Cic. *pro Milo.*) This or a similar instrument was also made use of against the Christians.

This instrument has been described as made of wood, with holes at certain distances, and provided with a screw, by means of which the victim was stretched to the third, fourth, or fifth hole, his arms and legs being fastened to the equuleus with cords. He was thus stretched till his bones were dislocated, and further tortured by the application of red-hot plates and a clawed instrument called *ungula.*

Equuleus, Equiculus, and Equus Minor, the horse's head, a constellation of the northern hemisphere. See Astronomy.

EQUUS. See Horse, and index to Mammalia.

ERA. See Æra, and Chronology.

ERANARCHA, among the ancient Greeks, a public officer who presided over the distribution of alms and provisions allotted for the poor. Cornelius Nepos, in his Life of Epaminondas, describes the office thus: When any person was reduced to poverty, taken captive, or had a daughter to marry and could not effect that object for want of money, the eranarcha called an assembly of friends and neighbours, and taxed each according to his means to contribute towards the relief of such person or persons.

ERASISTRATUS, a physician of Iulus, a town of the island of Ceos, now Zea, off Cape Sunium, in Attica, flourished from about 300 to 258 B.C. According to one account, he was grandson of Aristotle, his mother being daughter of that philosopher. He seems to have been in high favour at the court of Seleucus Nicator, whose son Antiochus he recovered from a dangerous illness in the following manner: Antiochus was violently enamoured of his mother-in-law Stratonice, and he determined to rid himself of life. His physician, Erasistratus, by close observation, perceived that Stratonice was the cause of his illness; and having informed his father, that monarch allowed his son to marry her. A similar story is told of many ancient physicians.

In his old age he renounced the practice of medicine, and, retiring to Alexandria, devoted himself more particularly to the study of anatomy. His description of the brain and nerves is said to have been far more correct than that of any of his predecessors. He was the founder of a school of medicine, which flourished long at Smyrna, and the disciples of which continued to exist till the time of Galen. Of his works only a few fragments remain, in the quotations of Galen and other writers.

ERASMUS, Desiderius, was born at Rotterdam on the 28th of October 1467.[1] His father, who bore the name of Gerard, was an inhabitant of Tergou; his mother, named Margaret, was the daughter of Peter, a physician of Sevenbergen. He had an elder brother, called Peter, but their parents were never married, though a promise of marriage is said so have preceded their intercourse. The brothers of Gerard, who was a young man of wit and gaiety, endeavoured to secure his patrimony by compelling him to become an ecclesiastic. Finding himself very uncomfortable in his own country, he went to Rome, where he employed himself in transcribing ancient authors; for the recent invention of printing had not entirely superseded this more slow and expensive method of multiplying copies of books. In the mean time, his relations sent him a false account of Margaret's death; and his grief for her supposed loss led him to adopt a resolution to which he could not be impelled by their importunities. Having taken orders, he returned to Holland, and found that she was still alive; but he could not now fulfil his promise of marrying her, and she never would marry another, nor did she continue to cohabit with him after he became a priest. He did not neglect the education of a son who was destined to reflect so much lustre on the age and nation to which he belonged. The boy was sent to school when he was only four years old; and, when he was still very young, his musical voice procured him a place among the choristers in the cathedral church at Utrecht. At the age of nine he was removed to the school of Deventer, where his master was Alexander Hegius, and one of his school-fellows was Adrianus Florentius, who continued to be his friend when, long afterwards, he was elevated to the papal chair, under the name of Adrian the Sixth. At this early period he exhibited uncommon powers of memory; and it has been said, perhaps with some degree of exaggeration, that he could repeat all Terence and Horace. His affectionate mother, who had likewise fixed her residence at Deventer, died of the plague when he was about thirteen; and his father, deeply affected with her loss, speedily followed her to the grave. They had both of them attained the age of about forty.

Gerard had recommended his hopeful son to the care of

[1] Bayle, *Dictionnaire Historique et Critique,* tom. ii. p. 1091. Several biographers refer the birth of Erasmus to the year 1465; but the inscription of his statue at Rotterdam assigns the date of 1467.

Peter Winckel, master of the school of Gouda, and to that of other two guardians, but they all seem to have been alike unworthy of such a trust; for with the view of dividing his slender patrimony among themselves, they agreed to urge upon him the necessity of embracing the monastic state. They accordingly compelled him to betake himself to a convent of friars at Bois le Duc in Brabant, where, as he has himself stated, he lost three years of his existence. No artifice or persuasion could at first induce him to become a friar, nor did any length of time subdue his utter repugnance to a monastic life. Even at this early period, as has been well remarked, he could discern that religion was the thing least regarded in religious houses. He was afterwards placed in the convent of Sion near Delft; and having next been removed to that of Stein near Tergou, he reluctantly submitted to pass his year of probation, and to take the vows as a canon regular of St Augustin. His brother, who had likewise been devoted to the monastic profession, made an abrupt retreat from his convent, and led a profligate and dissolute life; but Erasmus, though he also quitted his monastic state, to which, as Du Pin observes, "he had no inward vocation," conducted himself with sobriety, and prosecuted his studies with great assiduity. In 1490 he left the monastery to reside in the household of Henry de Bergues, bishop of Cambray; and in 1492 he was ordained priest by the bishop of Utrecht. He had quitted the convent with the consent of the bishop, of the prior, and of the general of the order. He wore the habit as long as he conveniently could; but when he resided in Italy he was obliged to lay it aside, on account of its resemblance to the dress of those who attended persons infected with the plague. From Julius the Second he obtained permission to wear it or not, according to his own convenience, but on condition of still bearing some mark of his order; and from the same pope, or from his successor Leo the Tenth, he obtained an absolution from his monastic vows. For the name of Gerardi he had substituted that of Erasmus, as bearing a more classical form, with the same signification. This name is of a Greek origin, though its proper form is Erasmius; and, prefixing a Latin name of similar import, he adopted the appellation of Desiderius Erasmus, instead of Gerard Gerardi.

In the year 1496 he was prosecuting his studies in the university of Paris, where he became a member of the College of Montaigu, and was led to contract a friendship with our learned countryman Hector Boyce, afterwards principal of King's College, Aberdeen. The bishop of Cambray, who was more liberal of his promises than of his money, had undertaken to assist him with a small pension; but as he excited hopes which were never realized, Erasmus was left to the usual expedients of a scholar placed in such circumstances. He laboured very diligently to increase his own stock of learning, and endeavoured to earn his subsistence by taking private pupils: thus he gradually established a high reputation, and secured the friendship of individuals distinguished by their rank and influence, as well as by their talents and learning. One of his pupils was Lord Montjoy, in whom he found a steady friend, and who afterwards bestowed upon him an annual pension of a hundred crowns. It was apparently through his connexion with this young nobleman that he was induced to visit England. The plague drove him from Paris in the year 1497; and after passing through the Netherlands, where he was kindly treated by the marchioness of Vere in the castle of Tornenhens, he proceeded to London and Oxford. He now formed an acquaintance with John Colet, afterwards dean of St Paul's, and with Thomas Linacre, William Grocyn, and William Latimer, three individuals who each contributed to promote among their countrymen a more general taste for the elegancies of classical literature. He is said to have resided for some time in St Mary's College, Oxford; but not long afterwards we again find him at Paris, and he likewise appears to have visited Orleans. His *Enchiridion Militis Christiani* he had begun in 1494, at the castle of Tornenhens, but it was not completed till after an interval of several years. This little book became very popular, and was translated into various languages. An English version, ascribed to Tindall, was printed by Wynkyn de Worde in 1533.[1] About the same period he was preparing one of his most elaborate works, the *Adagia*, first printed at Paris in 1500, and was strenuously applying himself to the study of the Greek language. He mentions to one of his correspondents, that as soon as he could get any money, he would first purchase books, and afterwards clothes. He had already published several of his smaller tracts, and had laid the foundation of that celebrity which long continued to increase, and which that of very few modern scholars has exceeded. He had not however secured any adequate provision; and as he lived somewhat precariously, and wandered from one place to another, he was too frequently compelled to solicit the bounty of those to whom fortune had been more propitious.

It appears from his correspondence that he was occasionally residing in Paris in 1504 and the two succeeding years. To the study of the Greek language, to which he closely applied for the space of three years, he was induced to add that of the Hebrew; but, as Dr Jortin has remarked, "he soon grew tired of the attempt, in all probability for want of proper instructors and helps; else he did things infinitely harder than it is to learn Hebrew." The necessity of taking pupils interfered with his own plans of study, and prevented him from executing some literary projects which he had now formed. In 1506 he again made his appearance in England, and is then supposed to have visited Cambridge. During the same year, he returned to Paris, and took with him the sons of J. Baptista Boeria, first physician to Henry the Seventh. He next directed his course towards Italy; and while he was prosecuting his journey on horseback, he composed a poem on the infirmities of old age, and addressed it to William Cope, another physician. Although he had not completed his fortieth year, he considered himself as already numbered with the aged. His constitution had never been vigorous; and he was subject to various distempers, which his habits of unremitting application to study did not contribute to alleviate. At an earlier period of life, he had expressed some anxiety to visit Italy, in order to take a doctor's degree; which, as he was sufficiently aware, makes one neither better nor wiser; "but it must be done," says he, "if a man would be esteemed in the world." He accordingly took the degree of D. D. in the university of Turin. Having resided about fifteen months at Bologna, when he superintended the education of Boeria's two sons, he afterwards went to Venice, and there published a third edition of his Adages. He spent a winter at Padua, and repaired to Rome in the ensuing year. At Venice he contracted an acquaintance with Marcus Musurus and Scipio Carteromachus, who taught the Greek language at Padua and Bologna; and he availed himself of so favourable an opportunity of ob-

[1] This was soon followed by another edition, printed by John Byddell, and bearing the following title: "Enchiridion Militis Christiani, whiche may be called in Englysshe the hansom Weapon of a Christen Knyght; replenyshed with many goodly and godly preceptes: made by the famous clerke Erasmus of Roterdame, and newly corrected and imprinted." Lond. 1534, 8vo. Many English translations from Erasmus are mentioned in Mr Lowndes's Bibliographer's Manual of English Literature, vol. ii. p. 673.

taining a solution of some of the difficulties which had occurred to him in the explication of Greek proverbs. It was at this period that he became the tutor of Alexander Stewart, a natural son of James the Fourth, by Margaret the daughter of Archibald Boyd of Bonshaw. His pupil, who was a youth of an amiable disposition and of promising talents, had been sent to the continent under the direction of Sir Thomas Halkerton, and, having travelled through France, became a student in the university of Padua; but it was at Sienna that he studied grammar and rhetoric under Erasmus, who has left a very pleasing account of his character, and who affectionately bewailed his premature death. At a very early age, he became archbishop of St Andrews, and obtained *in commendam* the abbacy of Dunfermline and the priorship of Coldingham. To these ecclesiastical preferments he added the office of lord chancellor; but having accompanied his father in the unfortunate expedition to England, he was slain, along with other warlike churchmen, at the battle of Floddon-field, before he had completed the twentieth year of his age.[1]

Erasmus experienced a gracious reception from the pope and some of the cardinals, but Rome had not sufficient attractions for a person of his disposition. We again find him in England about the beginning of the year 1510. On his arrival, he took up his abode with Thomas More, who was then a young man, and who afterwards rose to great eminence. It was at this period that he composed one of his most popular works, *Stultitiæ Laudatio*, or the Praise of Folly, which has been translated into all or most of the cultivated languages of Europe. In this lucubration, which he dedicated to his friend More, he treated the pope and the court of Rome with but little ceremony; so that, as Dr Knight has observed, "he was never after this looked upon as a true son of the church." The king, before the death of his father, had addressed a very friendly letter to Erasmus when he was in Italy, and he now received him with courtesy, although it does not appear that he ever bestowed upon him any very substantial proofs of kindness. To the king, as well as to Cardinal Wolsey, he owns himself indebted, not for magnificent benefits, but for magnificent promises. His chief patron was William Warham, archbishop of Canterbury, and chancellor of the kingdom; who, besides many occasional gratuities, bestowed upon him a living worth about a hundred nobles, the rectory of Aldington, near Ashford in Kent.[2] This however he speedily resigned, reserving to himself a yearly pension of twenty pounds; to which the archbishop added an equal sum from his own purse. He was invited to Cambridge by Dr Fisher, bishop of Rochester, president of Queen's College, and chancellor of the university, who entertained him in his own house, and procured him the appointment of Lady Margaret's professor of divinity, and that of Greek professor. Of these offices however, the honour appears to have exceeded the emoluments, nor did he long continue his residence at Cambridge. In the Greek chair he was succeeded by Richard Croke, who had previously taught that language in the university of Leipzig. His treatment in England reflects no particular credit on the character of those who had the chief distribution of ecclesiastical preferments. The king, though capable of perceiving his merit, had not sufficient generosity to reward it; and the lordly churchmen reserved their best benefices for those who had other recommendations to their protection and favour. He has himself stated that if the promises made to him had been realized, he would have spent the remainder of his days in England; but having been invited to Brabant, to the court of Charles archduke of Austria, he again returned to the Netherlands, where he appears to have been residing in the beginning of the year 1514. With the honorary title of counsellor to that prince, he obtained an annual pension of two hundred florins, which, if it had been regularly paid, would have placed him in circumstances sufficiently easy. He was presented to a canonry at Courtray, but this he likewise resigned, reserving to himself a pension out of its yearly revenue.

He had for some time been laboriously employed in preparing an edition of the Greek Testament; and in the course of the same year he proceeded to Basel, for the purpose of printing it at the celebrated press of Froben. He likewise carried with him the epistles of St Jerom, illustrated with his notes, and some other books intended for publication. To the writings of this father he had devoted much attention, and, on his arrival, he was therefore gratified to find that an edition of his works had already been sent to the press. His edition of the New Testament was first printed in 1516; and other editions issued from the same press in 1519, 1522, and 1527. At Basel he now spent several months, much to his satisfaction, and was particularly gratified with the reception which he experienced from the bishop of that see. Returning to the Netherlands, he learned that Charles, who afterwards became emperor of Germany, had nominated him to a vacant bishopric in Sicily, supposing it to be at his own disposal; and, finding the right of nomination belonged to the pope, that he had solicited this preferment for Erasmus. But the recommendation, which perhaps was not very urgent, failed to produce any effect; nor did he hear of any effort to procure him a bishopric, where the patronage was more free from entanglement. In the year 1515, he appears to have paid another visit to Basel, and likewise to England. To this country he made another excursion in 1517. Of the domestic habits of the English, he has drawn a picture which now seems not a little antiquated. The plague, from which that country was scarcely ever free, and the sweating sickness, he partly ascribes to the incommodious form and bad exposition of the houses, to the filthiness of the streets, and to the sluttishness within doors. "The floors," says he, "are commonly of clay, strewed with rushes, under which lies unmolested an ancient collection of beer, grease, fragments, bones, spittle, excrements of dogs and cats, and every thing that is nasty."

Francis the First had invited him to fix his residence in France, and had promised him a benefice of a thousand livres; but of this offer he could not be induced to avail himself. He still lingered in the Netherlands; and we find him occasionally residing at Louvain, the seat of a university which was long conspicuous for the bigotry of its theologians, some of whom had appeared as his professed antagonists.[3] An event of great moment in the history of mankind was now impending. In the memorable year 1517, the reformation of religion in Germany began by Luther's bold and decided opposition to the scandalous traffic in indulgencies; one of the most corrupt practices of a most corrupt church. From this beginning, apparently trivial, arose many important events; and although Erasmus did not possess the undaunted spirit of a genuine reformer, his writings were not without considerable influence in preparing the way for those salutary changes which

[1] Crawfurd's Lives of the Officers of State, p. 59. Edinb. 1726, fol.
[2] Knight's Life of Erasmus, p. 154. See Dr Middleton's Free Inquiry, p. cxxvi.
[3] Beatus Rhenanus mentions his having taught at Louvain. "Docuit Lovanii, Cantabrigiæ in Anglia, Lutetiæ etiam privatim, ubi theologiæ dedit juvenis operam." Erasmus, in his short account of his own life, has stated that he went to Louvain after he first returned from England.

Erasmus. now began to take place. The edge of his wit and ridicule was very sharply directed against monastic ignorance and grimace, against the vain observances which were so generally substituted for real piety.[1] Many of his publications had a powerful tendency to promote a critical knowledge of the Scriptures and of ecclesiastical antiquity, and consequently were opposed, though indirectly, to the cause of popery. But he never had the courage to avow his adherence to the cause of reformation; and he himself admitted that he was not endowed with the spirit of a martyr.[2] He was sufficiently ready to condemn the heat and violence of the German reformer: but the task undertaken by Luther was not to be executed by a man of a cool and balancing disposition; and without a large portion of his unflinching impetuosity and undaunted resolution, his disputation and his preaching would, to all human appearance, have been utterly unavailing. No sudden and beneficial change in the affairs of mankind will ever be effected by those who, like Erasmus of Roterdam, keep themselves aloof from all danger, and recommend gentleness and moderation to others, when they have to contend against temporal power, fortified by inveterate prejudice, and roused by the most intense feelings of selfishness.[3] He was however very far from approving of the violent proceedings of Luther's adversaries. In the year 1520, he was consulted at Cologn by Frederick elector of Saxony, and gave a very favourable opinion of the reformer. Luther, he remarked, has been guilty of two offences; he has touched the crown of the pope and the bellies of the monks. He added, in a more serious strain, that he had justly censured many abuses and errors, which it was necessary to reform and correct; that his doctrine was essentially right, but that it had not been delivered with a proper temper, and with due moderation. Although his conduct did not fully satisfy the Lutherans, it still less satisfied the papists. The publication of his *Colloquia* did not contribute to recommend the author to the genuine sons of the Romish church: it exposed him to new accusations of laughing at indulgencies, of disregarding auricular confession, and of deriding the pious use of fish, instead of flesh, on certain appointed days. This book, the most popular of all his performances, was published at Basel: an impression, said to consist of twenty-four thousand copies, was printed in 1527 by Colinet at Paris, and dispersed with amazing rapidity. The sale was promoted by a rumour, which is supposed to have been circulated by the printer, that the work was on the point of being suppressed. During the preceding year, the theological faculty of Paris had censured it as a book in which the fasts and abstinences of the church are slighted, the suffrages of the holy virgin and the saints are derided, virginity is placed below matrimony, Christians are discouraged from a monastic life, and grammatical is preferred to theological erudition. In the year 1549 a provincial council, held at Cologn, condemned the Colloquies of Erasmus as unfit to be read in schools.

The latter years of his life he spent in Switzerland, chiefly at Basel and Friburg. In the summer of 1522 he paid a visit to Constance, professing an intention of repairing to Rome, for the purpose of waiting upon his old school-fellow the new pope; but to one of his correspondents he mentions that he had fallen sick at the former city, and was deterred by rumours of war from prosecuting his journey. It is however more than probable that he had no great inclination to proceed. Adrian offered him a good deanery, which he did not think it advisable to accept; for he apparently considered it in the light of a retaining fee from the pope. In Switzerland he had many friends, and was only prevented from liking the country by the suffocating heat of the stoves, and the bad quality of the wine. Being subject to the stone and gravel, he found the new and acid beverage unsuitable to his constitution, and was obliged to procure wine from Burgundy. As he kept two servants and two horses, it may be inferred that he was enabled to live in sufficient comfort.

Ulrich von Hutten, a distinguished adherent of Luther, passing through the city of Basel in 1522, solicited an interview, which the caution of Erasmus prevented him from granting.[4] A slight of this nature was more than sufficient to rouse the vehement indignation of the German knight, who speedily discharged his spleen in a publication entitled "Ulrici ab Hutten cum Erasmo Roterodamo, Presbytero, Theologo, Expostulatio." This satirical effusion was followed by the "Spongia Erasmi adversus Aspergines Hutteni." Hutten's insolence and ferocity were blamed by Melanchthon, and by Luther himself.

In the year 1523, Adrian was succeeded in the papal chair by Clement the Seventh, who sent Erasmus an honourable epistle, accompanied with a donation of two hundred florins. After many solicitations from different quarters, he was at length induced to write against Luther, but not on a subject which involved the chief points of debate between the protestants and papists. His tract *De Libero Arbitrio* was printed in the year 1524. "Luther," says Dr Jortin, "was an admirer of Augustin, and, like the Thomists, held a physical predetermination, which entirely subverts human liberty, and which, under the pretence of making the creature dependent upon the Creator, deprives it of all active powers, so that it can do nothing without being necessarily determined by the influence of God. If there was any difference between Luther and the Thomists of the church of Rome, it was this, that Luther spake more simply and sincerely and openly than they; for he absolutely denied that there was any such thing as free-will, whilst they admitted it in words. This perhaps deceived Erasmus, who imagined that he was only disputing against Luther, whilst he was really disputing as much against Thomas Aquinas and his followers, as against the reformer. Be that as it will, Erasmus makes many good remarks against the sentiment which he opposes, and justly insists upon it, that the human will co-operates with the grace or assistance of God."[5] In 1525 Luther returned an answer, in a treatise *De Servo Arbitrio*, where his antagonist is treated with much scorn and contempt. Erasmus immediately replied in the first part of his *Hyperas-*

[1] Dr Robertson has remarked that "there was hardly any opinion or practice of the Romish church which Luther endeavoured to eform, but what had been previously animadverted upon by Erasmus, and had afforded him subject either of censure or raillery." (Hist. of Charles V. vol. ii. p. 142.) See likewise Archdeacon Blackburne's Confessional, p. 409. The worthy archdeacon describes Erasmus as "one of the most illustrious characters in all history."

[2] J. A. Fabricius has written a tract on the religion of Erasmus, which may be found in his *Opusculorum historico-critico-literariorum Sylloge*, p. 357. Hamb. 1738, 4to.

[3] "As the man," says Dr Paley, "who attacks a flourishing establishment writes with a halter round his neck, few ever will be found to attempt alterations but men of more spirit than prudence, of more sincerity than caution, of warm, eager, and impetuous tempers; consequently, if we are to wait for improvement till the cool, the calm, the discreet part of mankind begin it, till church governors solicit, or ministers of state propose it—I will venture to pronounce that (without His interposition with whom nothing is mpossible) we may remain as we are till the renovation of all things." (Sermons and Tracts, p. 43.)

[4] See Schubart's Leben und Charakter Ulrichs von Hutten, S. 131. zweit. Ausg. Leipzig, 1817, 8vo.

[5] Jortin's Life of Erasmus, vol. i. p. 335.

pistes, and the second part appeared in the year 1527; but, upon the whole, he appears to have had no reason to congratulate himself on the issue of the controversy.

About this period, Erasmus prepared various other works. In 1525 he published "Lingua, opus novum, et hisce temporibus aptissimum." In 1528 he published, in one volume, two of the most conspicuous of his literary compositions. The first bears the title, "De recta Latini Græcique Sermonis Pronuntiatione Dialogus;" the second, "Dialogus cui titulus, Ciceronianus, sive de optimo Genere Dicendi." Both these works were printed at Basel. His dialogue on the pronunciation of the classical languages excited much attention, and occasioned much controversy.[1] The pronunciation of Greek which then prevailed, was in some countries denominated the Reuchlinian, from its having been adopted by Reuchlin, who died in the year 1521, after having been chiefly instrumental in the introduction of classical learning into Germany. It essentially coincided with the pronunciation of the modern Greeks. In the copious grammar of Scot,[2] first printed in the year 1593, we still find the same system recommended. To the letter β he assigns the name of vita, to ζ of zita, to η of ita, to θ of thita. According to this system, the vowels η, ι, υ, and the diphthongs ει, οι, have no variety of sound, but ought to be pronounced as the French pronounce the letter *i*. Thus τη, τι, τυ, τει, τοι, have one and the same sound, instead of five distinct sounds. This however is not the only peculiarity of the system. Reuchlin's mode of pronunciation was almost entirely supplanted by that of Erasmus, although several learned men have at a much more recent period endeavoured to restore the old method. In his other ingenious dialogue, the *Ciceronianus*, he ridicules some modern scholars, chiefly Italians, who studiously rejected every word or phrase which had not been sanctioned by the authority of Cicero. Of the dead and the living he speaks with his usual freedom; nor did this publication contribute to diminish the number of his enemies. It was attacked with great ferocity by Julius Cæsar Scaliger, who writes in a style by no means Ciceronian.

In the year 1529, after the mass had been abolished at Basel, he removed to Friburg, where he purchased a house, and repaired it at considerable expense. In 1533 he published at Antwerp a treatise bearing the title of "Liber de sarcienda Ecclesiæ Concordia." On the same subject, he has introduced many suggestions into his epistles; but the peace of the church was not to be patched up by any expedients which Erasmus was capable of devising. His "Ecclesiastes, sive de Ratione Concionandi," appeared in 1535; and while it was printing at Basel, he returned to that city, and there he completed his earthly pilgrimage. On the accession of Paul the Third, a design was entertained of elevating Erasmus to the rank of a cardinal; but he had never been ambitious of ecclesiastical dignities, and now the state of his health was such as to deprive all sublunary honours of their usual attractions. The pope nominated him provost of the college of canons at Deventer; but already considering himself as standing on the verge of the grave, he declined an office which he probably would not have accepted in the vigour of his life. He had left Friburg in a bad state of health, nor were his maladies alleviated by his removal to Basel. He became worse during the summer, and for about a month was afflicted with dysentery. Disregarding those formal and minute devotions which he had so much derided in the monks, he fervently implored the mercy of God through Jesus Christ; and retaining his reason unimpaired till his last moments, he calmly expired on the 12th of July 1536, when he had nearly completed the sixty-ninth year of his age. A great concourse of people attended his funeral in the cathedral church of Basel. By his will, dated in the month of February, he bequeathed handsome legacies to several of his friends, and directed the residue of his property to be distributed by his executors, in relieving the poor and the sick, in marrying young women, and in assisting young men, such as they should judge to be necessitous and deserving.

Erasmus, though somewhat low in stature, was well formed, and had an easy and genteel air, nor was he slovenly or negligent in his apparel. He had a fair complexion, with grey eyes, and, during his youth, his hair was of a pale yellow. He had a cheerful countenance, with a low voice, and a pleasing elocution. He was a steady friend, and an agreeable companion; and indeed if his conversation displayed any portion of the wit and vivacity which distinguish his writings, his society could not fail of being delightful. Ardently devoted to letters, he kept his mind uncontaminated with that avarice and ambition by which churchmen have in too many instances been secularized. In disseminating a love of elegant letters among his contemporaries, he had no small influence, and equally conspicuous were his merits as a theologian. For the lifeless formalities of scholastic theology he had little respect, and less relish; but by his labours on the New Testament, and more especially by his publication and elucidations of the original text, he gave a new impulse to the students of that age, and directed their minds to a more edifying species of knowledge. To him belongs the honour of being the earliest editor of the Greek Testament; for although the Alcala edition, inserted in the Polyglot Bible, bears the imprint of 1514, it was not published till the year 1522. Of his paraphrase of the New Testament, an English translation was printed at an early period;[3] and so high was the estimation in which it was held, that a copy of it was directed to be placed in every parish-church in the kingdom.[4] The works of the ancient fathers of the church he had studied with much assiduity. To editions of Irenæus, Chrysostom, Cyprian, Hilary, Ambrose, Jerom, Augustin, and Arnobius the younger, he contributed more or less aid; and he translated particular treatises of Origen, Athanasius, Basil, and Chrysostom. His labours likewise served to render the writings of the ancient classics more accessible. Of the Geography of Ptolemy, the Greek text was first edited by Erasmus. He published editions of Livy, Seneca, Suetonius, and other authors; and if he seldom added notes, his prefaces were considered as no small recommendation. He translated into verse the Hecuba and Iphigenia of Euripides, and into prose detached works of Galen, Plutarch, Lucian, and Libanius. The labours of Erasmus were multifarious, and his compositions are very numerous; for our scanty limits have only afforded us an opportunity of specifying the more remarkable. An ample and elegant edition of his works

[1] Of this famous controversy a detailed account may be found in the Foreign Quarterly Review, vol. xiii. p. 60.

[2] Alexander Scot, LL. D. was a native of Scotland, but he appears to have spent the greatest part of his life in France, and to have exercised the functions of a judge at Carpentras. "Alexander Scotus Aberdonensis, magni nominis, sed majoris meriti, utriusque linguæ peritus, juris civilis scientia in paucis clarus, Carpentoractensis præfectus juri dicundo, quo in munere non minorem integritatis quam eruditionis famam acquisivit." (Dempsteri Historia Ecclesiastica Gentis Scotorum, p. 664.) We use the third edition of his *Universa Grammatica Græca*. Lugduni, 1614, 8vo. This is not the only work which Scot published.

[3] Lond. 1548–9, 2 vols. fol. The translation was executed by Miles Coverdale, Nicholas Udall, John Olde, and others. See Dr Dibdin's Typographical Antiquities, vol. iii. p. 491.

[4] Burnet's History of the Reformation, vol. ii. p. 27.

was published by Le Clerc, to whom we are likewise indebted for a discriminating account of the author's life and character.[1]

Dr Jortin has remarked that "the style of Erasmus is that of a man who had a strong memory, a natural eloquence, a lively fancy, and a ready invention, who composed with great facility and rapidity, and who did not care for the trouble of revising and correcting; who had spent all his days in reading, writing, and talking Latin; for he seems to have had no turn for modern languages, and perhaps he had almost forgotten his mother tongue. His style therefore is always unaffected, easy, copious, fluent, and clear, but not always perfectly pure and strictly classical. He hath been censured, as a dealer in barbarisms, by persons who not only had not half of his abilities and erudition, but who did not even write Latin half so well as he. His verses are plainly the compositions of one who had much learning and good sense, and who understood prosody, or the technical part of poetry, but who had not an equal elegance of taste, and an ear for poetical numbers. So that upon the whole he is rather a versifier than a poet, and is not to be ranked amongst the Italian poets of those days, Sannazarius, Fracastorius, Vida, &c., many of whom wrote better than any of the ancients, except Lucretius, Virgil, Horace, and a few more." (D. I.)

ERATO (from ἐράω, *I love*), in *Mythology*, the name of the muse who presided over amatory poetry. The invention of the lyre and the lute has by some been ascribed to this muse. She is represented with a garland of myrtles and roses, holding a lyre in one hand and a bow in the other, while at her side is seen a Cupid with his torch. One of the Nereids also bore the same name.

ERATOSTHENES, a celebrated astronomer and geometrician of Alexandria, was born at Cyrene B.C. 276. His father's name was Aglaus or Ambrosius. He was appointed superintendent of the great Alexandrian library by Ptolemy Euergetes, and died of voluntary starvation B.C. 196. His works, with the exception of the *Catasterismi*, or catalogue of the constellations, exist only in fragments. For a complete list of them see the *Eratosthenica* of Bernhardy. An account of his astronomical and geometrical discoveries is given under ASTRONOMY, *History of.*

ERATOSTRATUS, or more properly EROSTRATUS, an Ephesian who fired the famous temple of Diana the same night on which Alexander was born (B.C. 356), the watchful care of the goddess being withdrawn to attend the labour of Olympias. Having confessed that the desire to immortalize his name instigated him to the deed, Eratostratus was condemned by the Ephesians to eternal oblivion.

ERASTUS, or LIEBER, THOMAS, a German physician, who was the formal originator of the opinions now generally denominated *Erastian*. He was born at Baden in Switzerland in 1523; studied at Basle; and was professor of medicine at Heidelberg. He was afterwards professor of ethics at Basle, where he died in 1584. Erastus was the author of several medical works, but that for which he is chiefly known is the work on *Excommunication*, in which he promulgated his peculiar opinions; which are known under the name of Erastianism. He taught that the church had no right to refuse participation in the Lord's Supper, baptism, or other ordinances of the gospel, to any one, that it had no right to inflict excommunication or any kind of censure, and that the punishment of all offences, religious as well as civil, should be left in the hands of the civil magistrate.

ERBACH, a town of Hesse-Darmstadt, province of Starkenburg, on the Mümling, 24 miles S.E. of Darmstadt. Pop. 2100. It is the capital of a county formerly independent, but mediatized in 1806. The palace contains interesting collections of armour and antiquities. There are several other towns of this name in Germany.

ERBIL, a town of Persia. See ARBELA.

EREBUS, Ἔρεβος (from עֶרֶב, *night*), in *Mythology*, a term denoting darkness. According to Hesiod, Erebus was the son of Chaos and Night, and the father of the day. This was also the name of part of the infernal regions among the ancients; and a peculiar expiation was provided for those who were detained in Erebus.

Erebus was properly the gloomy region, and distinguished both from Tartarus the place of torment, and Elysium the region of bliss. According to the account given of it by Virgil, it forms the third grand division of the invisible world beyond the Styx, and comprehends several particular districts, as the *limbus infantum*, or the receptacle for infants; the *limbus* for those who had destroyed themselves; the fields of mourning, full of dark groves and woods, inhabited by those who died of love; and beyond these, an open champaign country for the accommodation of departed warriors.

ERECHTHEUS, or ERICHTHONIUS, an Athenian hero. See ATTICA, vol. iv., p. 192.

EREKLI, or EREGLI, the modern name of Heraclea, which see.

EREMITE. See HERMIT.

ERETHISM (ἐρεθισμός), in *Medicine*, a morbid degree of energy in the performance of any function.

ERETRIA, one of the most ancient and powerful cities of Eubœa, was situated on the western shore of the island in a south-easterly direction from Chalcis, from which it was not very far distant. Its inhabitants were a mixed race of Attic and Triphylian colonists; but the preponderating element in the city was Ionic. At an early period Eretria became famous as a maritime power; and the excellence of its position afforded it great facilities for the development of its resources in this direction. The great plain of Lelantum, at the southern extremity of which Eretria lay and at the northern Chalcis, was one of the most fertile spots in Greece. It was claimed by Eretria and Chalcis alike, and the contests for its possession gave rise to long and bloody feuds between the rival cities. In one of these the Eretrians were assisted by the Milesians, and in gratitude for this good office sent reinforcements to aid that people in their revolt from the Persians, B.C. 500. Ten years after this event, Eretria was besieged by Datis and Artaphernes, the generals of Darius. After a siege of six days it was taken and razed to the ground, and the inhabitants were carried off into slavery. A new town was soon after built a little south of the ancient site, and became a place of some importance. On the decay of the Athenian power, towards the end of the Peloponnesian war, the Eretrians joined the other Eubœans in throwing off the yoke of Athens. After this date Eretria experienced a variety of vicissitudes. It was at first governed by tyrants; and though a popular form of government was once more established with the aid of the Athenians, it finally became subject to Macedonia. On the overthrow of that kingdom by the Romans at Cynoscephalæ, Eretria was again declared to be free. Of the subsequent history of the city and its final decay, nothing is known. No remains of Old Eretria now exist, but considerable ruins of the new city may still be traced near the modern Vathy.

[1] Desiderii Erasmi Opera omnia emendatiora et auctiora. Lugd. Bat. 1703–6, 10 tom. fol. Le Clerc's account of Erasmus, chiefly derived from his letters, may be found in the *Bibliothèque Choisie*, tom. v., p. 145, tom. vi., p. 7. His other biographers are numerous; and we shall mention the most considerable Lives which have appeared in a separate form. Knight's Life of Erasmus, more particularly that part of it which he spent in England. Cambridge, 1726, 8vo. Burigny, Vie d'Erasme. Paris, 1757, 2 tom. 12mo. Jortin's Life of Erasmus. London, 1758–60, 2 vols. 4to. Hess's Erasmus von Roterdam nach seinem Leben und Schriften. Zürich, 1790, 2 Bde. 8vo. Of M. de Burigny's work, a German translation, with corrections and additions, was published by Professor Henke. Halle und Helmstädt, 1782, 2 Bde. 8vo. Dr Knight's work had been translated into the same language by Theodor Arnold. Leipzig, 1735, 8vo.

For an account of the Eretrian school of philosophy, founded by Menedemus, a native of the place and a disciple of Plato, see MENEDEMUS.

ERFURT, a city of Prussian Saxony, capital of a cognominal government, on the Gera, 14 miles E. of Gotha, and about the same distance W. of Weimar. It was formerly the capital of Thuringia, and is a fortress of the second class, being of importance on account of its position on the high road between Frankfort and Leipzig. It has two citadels, the one Petersburg, within the walls, the other Cyriaksburg, on Mount Cyriaks, outside the town. Erfurt is an old, dull, and irregularly built town, having no street or square worthy of notice, except the market place which is ornamented with a stone obelisk 50 feet high, erected in 1802 to Charles, Elector of Mayence. The cathedral is a fine Gothic building standing on an eminence, and having a famous bell (called the Susanna) 10 feet high, 30 feet in circumference, and weighing 275 cwt. The largest and finest church after the cathedral is the Predigerkirche. The church of St Severus is distinguished by its three towers. The Barfüsserkirche, of which a part fell in 1838 but has since been restored, is also worthy of notice. In the beginning of the present century Erfurt had eight convents, but of these only one now remains, the Ursuline nunnery, in connection with which is a female school. The Augustine monastery, which Luther entered as a monk on 17th July 1505, is now used as an orphan asylum. The cell which he inhabited is still preserved in its original condition, and contains his portrait, bible, and other relics. The university established here towards the end of the fourteenth century was suppressed in 1816. There are, however, a botanic garden, observatory, anatomic theatre, and a public library of about 50,000 volumes. Among the other educational institutions, which are numerous, may be mentioned a Roman Catholic and a Protestant gymnasium, a normal school, midwifery school, deaf-mute and blind institutions, a royal academy of popular sciences, trade and commercial schools. In the time of Charlemagne this was one of the chief commercial cities of Germany, and it afterwards became a member of the Hanseatic League. In the end of the sixteenth century it is said to have had as many as 58,000 inhabitants. It was first annexed to the Prussian dominions in 1803, and from 1807 to 1813 was in the possession of the French. In 1808 the memorable interview between Napoleon and the Emperor Alexander of Russia took place here. It was restored to Prussia in 1814. In 1849 Erfurt contained 32,224 inhabitants, including 5561 military: of these 25,438 were Protestants, 6619 Roman Catholics, and 167 Jews. They are chiefly employed in the manufacture of linen, woollen, and cotton goods, and silk ribands; and in shoemaking, and the rearing of garden produce. The government comprehends nine circles, and has an area of 1306 square miles. Pop. (1849) 347,279, of whom 247,332 were Protestants, 98,485 Roman Catholics, and 1457 Jews. Pop. (1852) 350,781.

ERGASTULUM, among the ancient Romans, a kind of work-house or private prison, usually attached to farms, where the slaves were made to work in fetters. It was usually under ground; and from this dungeon the unhappy inmates were led forth in chains to cultivate the fields. Confinement in the Ergastulum was also used as a punishment for disobedient or intractable slaves, who frequently experienced in these dungeons great severities. At length, after various enactments for ameliorating the condition of slaves, the ergastula were entirely abolished by Hadrian.—(See Spart., *Hadrian*, 18; Plutarch, *Tib. Gracch.* 8.)

ERGOT (Fr. *ergot, a cock's spur*), a disease caused in rye and some other grasses by the attack of a fungus called *Ergotætia abortans*, which induces a morbid condition in the ovarian cells. See BOTANY, vol. v., p. 172. Rye thus affected is highly poisonous, and has sometimes caused death by a kind of mortification called dry gangrene. Ergot is a valuable agent employed in obstetric practice for promoting the contraction of the uterus.

ERICACEÆ, the heath order of plants. See BOTANY, Nat. Ord. 131.

ERICIUS, in *Roman Antiquity*, a military engine, so named from its resemblance to a hedge-hog. It was a kind of chevaux-de-frise, and was placed as a defence at the gate of the camp.

ERIDANUS, a river celebrated in ancient mythology as that into which Phaethon is said to have fallen when struck by the lightning of Jupiter, and on whose banks his sisters bewailed his loss so bitterly that they were changed into long and slender poplars, and their tears into amber. By the later writers this river has been identified with the *Padus* or Po, but the absence of amber there, and other circumstances, have led to the belief that the Eridanus of the earlier writers is to be sought for among the more northern rivers of Europe. Cluverius has suggested that the Eridanus of Herodotus may be the *Rhodaune*, a tributary of the Vistula; whilst others, knowing that amber was the staple production of the Baltic, are inclined to believe it to be the name applied to that sea by mythologists, who were little acquainted with geography.

ERIDANUS, in *Astronomy*, a constellation of the southern hemisphere, containing 84 stars.

ERIE, a lake of North America. See CANADA.

ERIGENA, JOANNES SCOTUS, a famous scholastic divine, was born about the beginning of the ninth century; but the place of his birth is a matter of considerable uncertainty. Bale and Pitts affirm that he was born at St David's in Wales; Dempster, Mackenzie, and Henry, that he was a native of Scotland. Dempster contends that he was born at Ayr, and in order to suit the name to the hypothesis, he describes him as Joannes Airigena. Du Pin, Sir James Ware, and Dr Ledwich have with greater probability asserted that he was by birth an Irishman, Ireland being then called *Scotia*, and by the natives *Erin.* Various writers agree in relating that he travelled to Athens, where he acquired a competent knowledge of the Greek and oriental languages; and that he afterwards resided many years at the court of Charles the Bald, king of France, who, on account of his singular abilities, treated him as his intimate friend and companion. He slept frequently in the royal apartment, and was constantly admitted to the king's table. "We may judge," says a modern historian, "of the freedom which he used with Charles, by the following repartee. As the king and Scotus were sitting one day at table, opposite to each other, after dinner, drinking a cheerful glass, the philosopher having said something that was not quite agreeable to the rules of French politeness, the king in a merry humour asked him, Pray, what is between a *Scot* and a *sot?*" To which he answered, "Nothing but the table."[1] During his residence with Charles, he wrote several books of scholastic divinity, but was not so fortunate as to escape the imputation of heterodoxy. On that account the pope commanded Charles to send him to Rome; but the king had too great a regard for his companion to trust him with his holiness. One of the chief controversies in which Erigena was engaged, and with which the pope was much offended, was concerning the real presence. His opinion of this weighty matter is expressed in these few words:—"What we receive corporally is not the body of our Lord, but that which feeds the soul, and is only perceived by faith."

Whether Erigena ended his days in France is a matter of doubt. Some historians relate that he quitted it in 864; and that, after residing about three years in Oxford, he re-

[1] Henry's *History of Great Britain*, vol. i., p. 344.

tired to the abbey of Malmesbury, where his scholars stabbed him with their pen-knives. There is no foundation for this story. Probably he died about 874; but whether in France or England, is uncertain, and of little importance. Some have related that he was invited to England by King Alfred; but they have apparently confounded him with John abbot of Etheling, who was assassinated in 895; and to this mistake the various accounts concerning Erigena are to be attributed. Amongst other works, he composed the following:—1. *Excerpta de Differentiis et Societatibus Græci Latinique Verbi.* 2. *De Divisione Naturæ lib. v.* 3. *De Prædestinatione Dei.* 4. *De Visione Dei.* 5. *De Corpore et Sanguine Domini.* 6. *Ambigua S. Maximi, seu Scholia ejus in difficiles locos S. Gregorii Nazianzeni, Latine versa.* 7. *Opera S. Dionysii quatuor in Latinam linguam conversa.* Most of these works have been printed. There is an edition of his books *De Divisione Naturæ.* Oxon. 1681, fol. The author was formerly denominated the Glory of the Greeks; an appellation to which, in the opinion of Montfaucon, he was not sufficiently entitled.[1] For the age in which he lived, he however appears to have been a person of eminent learning; and his translation of Dionysius Areopagita has received no mean commendation from Huet.[2]

ERIGONE, in *Grecian Mythology*, daughter of Icarus. Dying of grief on account of her father's death, she was translated to heaven, and formed the sign Virgo. See EORA.

ERINITE, a native arseniate of copper, of a fine emerald-green colour. It was found at Limerick in Ireland—whence the name.

ERINNA, a Greek poetess, the friend and contemporary of Sappho, from her intimacy with whom, although born in Rhodes, she is frequently called a Lesbian. Of her poems, which attained the highest celebrity in ancient times, only a few lines are now extant. Another poetess of this name is said to have flourished in the age of Demosthenes, but her existence is matter of considerable uncertainty.

ERINNYES, another name for the Eumenides, or Furies. See FURIES.

ERIOMETER (ἔριον, *wool*, and μέτρον, *a measure*), an instrument invented by Dr Young, for measuring the fineness of the fibres of wool, by ascertaining the diameter of any one of the series of coloured rings they produce. See CHROMATICS, vol. vi., p. 651.

ERIPHYLE, the daughter of Talaus and Lysimache, and wife of Amphiaraus. By the gift of a necklace she was bribed by Polynices to reveal the hiding-place of her husband, who was unwilling to accompany the Argives against Thebes. Her faithlessness was avenged by Alcmæon her son, who put her to death as soon as he had learned that his father had perished in the expedition.

ERIS, the goddess of discord among the Greeks. She is the same as the *Discordia* of the Latins.

ERIVAN or IRWAN, a fortified town of Russian Armenia, and capital of a cognominal province, is situated on the Zengui, an affluent of the Araxes, 110 miles S.S.W. of Teflis. The town is of considerable extent, but it is interspersed with numerous gardens, and a great part of it is in ruins. Pop. only about 12,000. It is defended by a citadel standing on a steep rock 600 feet in height, overhanging the river. This fortress is about 2000 yards in circumference, and contains the ancient palace of the Khans, now the residence of the governor, a fine mosque, a cannon foundry, and barracks. The town is ill built, but contains a large bazaar, a Greek and several Armenian churches, an Armenian convent, and several mosques. There is a handsome stone bridge across the river. Erivan has a considerable trade, and is a station for caravans from Teflis to Erzeroum. It has also some manufactures of cotton stuffs, leather, and earthenware, and is noted for the excellence of its fruits and melons. Erivan was taken by the Russians in 1827, and confirmed to them by treaty with Persia the following year.

ERLANGEN, a town of Bavaria, circle of Middle Franconia, near the Regnitz, eleven miles N. of Nürnberg, and on the railway between that town and Bamberg. It is surrounded by walls, and divided into an old and new town, the latter consisting of wide, straight, and well-built streets. Erlangen is noted for its university, the only Protestant one in Bavaria. This institution was founded by Frederick margrave of Bayreuth in 1743. The average attendance of students is about 350. It occupies the ancient palace of the margraves of Bayreuth, and has faculties of arts, medicine, and theology, museums of natural history, a botanic garden, and a library of upwards of 100,000 volumes. The town owes its prosperity chiefly to the French Protestant refugees, who settled here on the revocation of the edict of Nantes, and introduced various manufactures. Erlangen has manufactures of woollen and cotton goods, hosiery, hats, leather, gloves, and plate-glass. Pop. (1852) 10,910.

ERLAU (Hung. *Eger*, Slav. *Jager*, Lat. *Agria*), a fortified town of Hungary, capital of the county of Heves, situated in a beautiful and fertile valley on both sides of the Erlau, an affluent of the Theiss, 67 miles N.E. of Pesth. Pop. about 20,000, most of whom are Catholics. Previous to 1802 it was the seat of a bishop, but since that period it has been the seat of an archbishop. It is inclosed by old walls, and entered by six gates. On an eminence above the town stands the old castle, which was frequently besieged during the Turkish wars, both by Moslem and Christian. The principal edifices in the town are the cathedral, built in the form of a Latin cross and surmounted by a cupola, the Archbishop's palace, the lyceum, with a library and observatory, the county hall, and the new barracks. Besides the cathedral it has four Roman Catholic churches, a Greek and a Protestant church, and two monasteries. There are also a Roman Catholic high school and ecclesiastical seminary, gymnasium, hospital, and several libraries. The vicinity is highly cultivated, and produces fine red wines and tobacco. The manufactures are linens, woollens, hats, leather, &c.

ERMIN, an order of knights instituted in 1450, by Francis I., Duke of Bretagne, and which formerly subsisted in France. The collar of this order was of gold, composed of ears of corn in saltier, at the end of which hung the ermine, with the inscription *à ma vie.* But the order expired when the dukedom of Bretagne was annexed to the crown of France.

ERMINE, an animal of the genus *Mustela*, an inhabitant of northern climates in Europe and America. It nearly resembles the marten in shape, but the weasel in its habits. During summer the upper part of the body is of a pale tawny brown colour, and the tail tipped with black; but in winter the fur assumes that snowy whiteness for which it is so much admired.

ERMINE, and ERMINES, and ERMINOIS, in *Heraldry*. See HERALDRY, § *Of Furs.*

ERNE, LOUGH. See FERMANAGH.

ERNESTI, JOHN AUGUSTUS, one of the most illustrious philologers and theologians of the last century. He was born Aug. 4, 1707, at Tennstadt, of which place his father, likewise a distinguished theologian, was pastor, and superintendent of the electoral dioceses of Thuringia, Salz, and Sangerhusen. After having received his first instruction in the learned languages under the domestic discipline of his father, and in the gymnasium of his native town, he was sent at the age of sixteen to the celebrated Saxon

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[1] Montfaucon, *Palæographia Græca*, p. 42.

[2] Huetius, *de Interpretatione*, p. 154.

cloister school of Pforta. Here he continued four years. At the age of twenty he entered the university of Wittemberg, where he studied eloquence and ancient literature under the celebrated Berger, theology under Wernsdorf, and the Wolfian philosophy under Schlosser. From Wittemberg he passed to the university of Leipzig, where he applied himself to the mathematical sciences under Hausen, following the courses of Boerner and Deyling on theology, and the lectures of Gottsched on German eloquence. In 1730 he was made master in the faculty of philosophy. In the following year he accepted the office of corrector in the Thoman school of Leipzig, of which J. M. Gesner was then rector; and on Gesner's vocation, as professor of eloquence, to Göttingen, he succeeded him as rector. He was, in 1742, named extraordinary professor of ancient literature in the university of Leipzig, and in 1756 promoted to the ordinary professorship of eloquence. Here his reputation as a scholar, and his rational treatment of the biblical exegesis, paved the way for his entrance into the theological faculty. Through the elegance of his learning, and his manner of discussion, he co-operated with Baumgarten of Halle in disengaging dogmatic theology from the scholastic and mystical excrescences with which it was then deformed, and thus paved the way for a revolution in theology. In these deserving labours, and with unbroken health, he attained an honourable old age; and died, after a short illness, in his seventy-sixth year, Sept. 11, 1781.

As a philologer or theologian, it is perhaps as much from the impulse which Ernesti gave to sacred and profane criticism in Germany, as from the intrinsic excellence of his own works in either department, that he must derive his reputation. With Gesner, he instituted a new school in ancient literature; and after Crocus, Melanchthon, and Camerarius, has been perhaps the greatest reformer and promoter of classical learning in Germany. With Semler he partially co-operated in the revolution of Lutheran theology; though he is guiltless of all participation in the deductions which many of those who profess themselves his disciples have drawn from the principles which he established.

From the Reformation down to the latter half of the eighteenth century, Germany was far excelled by Holland in the number and excellence of her philologers; and it was not until the appearance of Gesner and Ernesti, with their somewhat earlier contemporaries, Cortius, Daniel Longolius, and Michael Heusinger, that she could oppose above one or two rivals to the great critics of the Dutch schools. Gesner and Ernesti, however, through the influence of their lectures at the greater universities of Göttingen and Leipzig, through the wider extent of their labours in philology, and still more through the greater excellence of their methods, are entitled to be held the founders of the new German school of ancient literature. Both, but especially Ernesti, have detected grammatical niceties in the Latin tongue which had escaped all preceding critics; such, among others, are the use of the subjunctive mood after the pronoun *qui*, and the legitimate consecution of the tenses. His canons are, however, not without exceptions. As an editor of the Greek classics, Ernesti deserves hardly to be named beside his Dutch contemporaries, Hemsterhuis, Valkenaer, Ruhnken, or his colleague and enemy the learned and unfortunate Reiske. How insignificant are his own labours in his editions of Homer and Callimachus! In regard to the higher criticism, it was not even attempted by Ernesti. But to him and to Gesner the peculiar praise is owing of having formed, partly by their discipline, and partly by their example, philologers greater than themselves; and to them is due the honour of having kindled the national enthusiasm for ancient learning.

As a theologian, Ernesti is far less conspicuous than as a scholar, and his influence not so marked either on his contemporaries or on his successors. He began his career when the Speneriau pietism had been almost banished from the Lutheran theology; when to the study of theology, philosophy had been imperfectly applied, and without any interesting result, by Baumgarten, a scholar of Wolf; and historical interpretation had, in the hands of Semler, been productive of conclusions subversive of much that had been hitherto held orthodox and even sacred. In the grammatical interpretation of the New Testament some imperfect progress had been made by Bengel; but the new epoch in the biblical exegesis commences with John David Michaelis for the Old, and with Ernesti for the New Testament. It is, indeed, chiefly in *hermeneutics* that Ernesti has any claim to the character of a great theologian. But here his merits are distinguished, and, at the period when his *Institutio Interpretis N. T.* was published, almost peculiar to himself. In it we find the principles of a general interpretation, formed without the assistance of any particular philosophy, not even of the Wolfian, to which Ernesti was attached; but consisting of observations and rules, which, though already enunciated, and applied in the criticism of the profane writers, had never rigorously been employed in the biblical exegesis. He admits in the sacred writings as in the classics only *one acceptation*, and that the *grammatical*, convertible into and the same with the *logical* and *historical*. He therefore justly censures the opinion of those who, in the illustration of the Scriptures, refer everything to the illumination of the Holy Spirit; as well as that of others who, disregarding all knowledge of the languages, would explain words by things, and thus introduce into the holy writings their peculiar glosses and opinions. The *analogy of faith*, as a rule of interpretation, he greatly limits, and teaches that it can never alone afford the explanation of words, but only determine the choice among their possible significations, and must always stand in need of philology as an assistant. The spirit of Ernesti's interpretation gives no countenance, however, to the results which many of his followers have deduced from the grammatical and historical exegeses. Every principle of his interpretation rests on the assumed inspiration of the holy books; and there is not perhaps a better antidote to the poisonous tenets of many of those who profess to be of his school, than the diligent study of his *Interpres*, and the relative *Acroases* of Morus. In the higher criticism of the sacred books Ernesti did nothing. In dogmatic he always expressed great contempt of strict systematic theology; and though he lectured for many years on the Aphorisms of Neumann, it was rather in refutation than in support of his text-book.

Among his works the following are the more important:—I. In classical literature: *Initia Doctrinæ Solidioris*, 1736, 8vo, many subsequent editions; *Initia Rhetorica*, 1730; *Xenophontis Memorabilia Socratis, cum notis*, 1737, often reprinted; *Ciceronis Opera cum clave*, 3d ed., 1776; *Suetonius cum Animadversionibus*, 2d ed., 1775–8; *Taciti Opera cum notis J. Lipsii, Jo. Fr. Gronovii et suis*, 2d ed., 1772; *Aristophanis Nubes cum Scholiis Antiquis et præfatione*, 1754, 8vo; *Corradi Quæstura cum præfatione*, 1754, 8vo; *Hederici Lexicon Græcum, multis Vocabulorum millibus Auctum*, 1754–67, 8vo; *Homeri Opera Omnia, ex Recensione, et cum Notis Sam. Clarkii, accessit Varietas Lectionum MS. Lips. et Edit. Vet. cura J. A. E. qui et suas Notas adspersit*, 1759–64, 5 vols. 8vo; *Callimachi Hymni et Epigrammata, cum Notis Var. Latine vertit atque Notis adjecit*, Lugd. Bat. 1761, 8vo, 2 vols.; *Polybius cum Notis Var. Præfationem et Glossarium Polybianum adjecit*, Viennæ et Lips. 1764, 3 vols. 8vo; *Archæologia Litteraria*, 1768, a new and improved edition by Martini; *Horatius Tursellinus de Particulis*, 1769, 8vo; *Fabricii Bibliotheca Latina nunc melius delecta, rectius digesta et aucta*, vols. i. and ii. 1773, vol. iii. 1774, 8vo, unfinished. II. In sacred literature: *Antimuratorius sive Confutatio Disputationis Muratorianæ de rebus Liturgicis*, 1755–58; *Neue Theologische Bibliothek*, vols. i. to x. 1760–69, 8vo; *Institutio Interpretis Nov. Test.*, 3d ed., 1775, 8vo; *Neueste Theologische Bibliothek*, vols. i. to x. 1771–75, 8vo. Besides these, he published above a hundred smaller works in the form of prefaces, academical dissertations, programmata, memoriæ, elogia, epistles, orations, translations, &c. Many of these have been collected in the three following publications:—*Opuscula Oratoria*, Lugd. Bat. 1762,

2d edit. 1767, 8vo; *Opuscula Philologica et Critica*, Lugd. Bat. 1764, 2d edit. 1776, 8vo; *Opuscula Theologica*, Lips. 1773, 8vo.

Ernesti, *Augustus Wilhelm* (1733–1801), the nephew of the preceding, was professor of philosophy at Leipzig, and afterwards succeeded his uncle in the chair of eloquence in that city. He is principally known from his edition of Livy. He was in turn succeeded by his cousin Johann Christian Theophilus (1756–1802), who published amongst other works a *Lexicon Technologiæ Græcæ Rhetoricæ; Lex. Tech. Romanorum Rhetoricæ*, a translation of Dumesnil's *Latin Synonyms*, and of several of Cicero's works.

EROS, the Cupid of the Greeks. See Cupid.

EROSION (*e* and *rodo, I gnaw*), the act or operation of eating away; corrosion; canker.

EROTIA, or Erotidia, a festival in honour of Eros, the god of love, celebrated by the Thespians every fifth year, with games and contentions in music and poetry. See Cupid.

EROTIC (ἐρωτικός, from ἔρως, *love*), pertaining to, or treating of love.

EROUAD, or Erroad, a town of Hindustan, in the province of Coimbetoor. It contained during the reign of Hyder about 3000 houses, but was reduced to one-third in the reign of Tippoo; and during the invasion of General Meadows the town was destroyed. It is now fast recovering, and contains a considerable population. It was taken by the British in 1768, and retaken the same year by Hyder. It was again taken by the British in 1790, and retaken by Tippoo; but it came into the final possession of the British, along with the province, in 1799. A canal of irrigation cut in its vicinity has been productive of much benefit to the inhabitants. E. Long. 77. 46., N. Lat. 11. 19. (E. T.)

ERPENIUS or d'Erpe, Thomas, a celebrated orientalist, born at Gorcum in Holland, on the 7th September 1584. Observing his aptitude for learning, his father sent him to Leyden at the early age of ten; and it was in that city that he commenced his studies. At the end of several months, however, he went to Middelburg, but he soon after returned to Leyden. He was early admitted into the university of that city, and in 1608 took the degree of master of arts. By the advice of Scaliger he learned the oriental languages whilst taking his course of theology, and even then gave promise of great distinction in that department of learning. He afterwards travelled in England, France, Italy, and Germany, forming connections with learned men, and availing himself of the information which they communicated. During his stay at Paris, he contracted a friendship with Casaubon, which lasted during his life; and also took lessons in Arabic from Joseph Barbatus, otherwise called Abu-dakni. At Venice he perfected himself in the Turkish, Persic, and Ethiopic languages. After a long absence, Erpenius returned to his own country in 1612, rich in the learning which he had acquired during his travels, as well as beloved by all the learned whom he had visited. His acquirements being already known and appreciated, he was, on the 10th February 1613, appointed professor of Arabic and other oriental languages, Hebrew excepted, in the university of Leyden. From this period he devoted himself solely to the teaching of these languages; and animated by the example of Savary de Brèves, who had established an Arabic press at Paris at his own charge, he caused new Arabic characters to be cut at a great expense, and erected a press in his own house. In 1619 the curators of the university of Leyden instituted a second chair of Hebrew in his favour. In 1620 he was sent by the States of Holland to induce Pierre Dumoulin or André Rivet to settle in that country; and after a second journey he was successful in inducing Rivet to comply with their request. Some time after the return of Erpenius, the States appointed him their interpreter; and in this capacity he had the duty imposed upon him of translating and replying to the different letters of the Moslem princes of Asia and Africa. The reputation of Erpenius had now spread throughout all Europe; and several princes, the kings of England and Spain, and the archbishop of Seville, made him the most flattering offers; but he constantly refused to leave his native country, and died of a contagious distemper Nov. 13, 1624, at the early age of forty. Erpenius left several works, which are doubtless disfigured by imperfections; but if we consider that he lived in an age when pursuits like his were exceedingly rare, if not wholly new, and that he had little or no assistance of any kind; and if we judge him, not according to the present state of oriental literature, but by what he actually achieved under every disadvantage, we must conclude that, in the immensity and difficulty of his labours, he probably surpassed all the orientalists who have followed him; and that if his career had not been cut short by a premature death, he would have greatly enlarged the boundaries of that literature of which his name will always remain one of the greatest ornaments.

The following is a list of his works:—*Oratio de Lingua Arabica*, Leyden, 1613, in 4to; *Annotationes in Lexic. Arab. Fr. Raphelengii*, ibid. 1613, in 4to; *Grammatica Arabica, quinque libris methodice explicata*, ibid. 1613, in 4to; *Proverbiorum Arabicorum centuriæ duæ, ab anonymo quodam Arabe collectæ*, ibid. 1614 and 1623, in 8vo; *Locmani sapientis Fabulæ et selecta quædam Arabum Adagia, cum interpretatione Latina et notis*, ibid. 1615, in 8vo; *Pauli Apost. ad Romanos, Arabice*, ibid. 1615, in 4to; *Novum D. N. J. C. Testamentum, Arabice*, ibid. 1616, in 4to; *Pentateuchus Mosis, Arabice*, ibid. 1622; *Historia Josephi Patriarchæ ex Alcorano, cum triplici versione Latina et scholiis Th. Erpenii, cujus præmittitur Alphabetum Arabicum*, ibid. 1617, in 4to; *Grammatica Arabica dicta Giarumia et libellus centum regentium cum versione Latina et Commentariis*, ibid. 1617, in 4to; *Canones de litterarum Alif, Waw, et Yè apud Arabes naturo et permutatione*, ibid. 1618, in 4to; *Rudimenta Linguæ Arabicæ; accedunt Praxis Grammatica et consilium de studio Arabico feliciter instituendo*, ibid. 1620, in 8vo; *Orationes tres de linguarum Ebreæ et Arabicæ dignitate*, ibid. 1621, in 12mo; *Historia Saracenica*, ibid. 1625, in fol.; *Grammatica Ebræa Generalis*, ibid. 1621, in 8vo; *Grammatica Syra et Chaldæa*, ibid. 1628; *Psalmi Davidis, Syriace*, ibid. 1628; *Arcanum punctuationis revelatum et Oratio de nomine Tetragrammato; Versio et Notæ ad Arabicam Paraphrasin in Evang. S. Joannis*, Rostock, 1626; *De Perigrinatione Gallicâ utiliter instituenda tractatus*, ibid. 1631, in 12mo; *Præcepta de Lingua Græcorum communi*, Leyden, 1662. Erpenius had projected several other works, particularly an addition of the Koran with notes, and an oriental library; and in the prefaces of his grammars he also speaks of a *Thesaurus Grammaticus*, which, however, has not seen the light. For further information respecting this celebrated orientalist, the learned reader may consult Vossius, *Oratio in obit. Th. Erpenii*, Leyden, 1625, in 4to, and Scriverius, *Manes Erpeniani, quibus accedunt Epicedia variorum*, ibid. 1625.

ERPETOLOGY, that part of natural history which treats of reptiles. See Reptilia.

ERRATIC (*errare, to wander*), wandering, not stationary. This term is applied to the planets as distinguished from the fixed stars. Geologists give the name of *erratic blocks* to those weather-worn and more or less rounded fragments of the harder rocks which are found scattered over the surface of the earth at great distances from the places whence they are supposed to be derived. Those of a middling size are usually termed *boulders*.

ERRHINE (ἐν and ῥίν, *the nose*), any medicine to be snuffed up the nose in order to promote the natural discharge.

ERROR, in *Philosophy*, a mistake of the judgment. The causes of error are reduced by Locke into these four: want of proofs; want of ability to use them; want of will to use them; and wrong measures of probability.

Error, in *Astronomy*, the amount of difference between the positions of any of the celestial bodies as determined by calculation and by observation.

Error, *Writ of*, in *Law*, a writ founded on an alleged error in judgment, which carries the suit to another tribunal for redress.

ERSE, a name given to the language spoken by the descendants of the Gaels or Celts in the Highlands of Scotland; the Highlanders being supposed by their Gothic neighbours to be an *Irish* colony, who thence called their language *Erse*, which is a corruption of the word *Irish*. The term *Gaelic* is that invariably applied to their language by the Highlanders themselves. See LANGUAGE.

ERSKINE, EBENEZER, a celebrated divine, and founder of the Secession Church in Scotland, was born June 22, 1680, according to one account at the village of Dryburgh, but according to another, at the Bass, where his father, who had been ejected in 1662 from his charge in Northumberland, was for some time a prisoner. He received his education at Edinburgh, and was settled in 1703 in the parish of Portmoak. There he remained for twenty-eight years, after which, in the autumn of 1731, he was translated to Stirling. Previously to this period, however, his extraordinary popularity had made him an object of jealousy to the clergy generally, who entertained a peculiar fondness for the abjuration oath, lay patronage, and legal theology. For his vigorous defence of the evangelical doctrines contained in the *Marrow of Modern Divinity*, Erskine received the rebuke of the Assembly, and was exposed to the most vehement abuse both in the church courts and from the public press. A sermon which he preached on lay-patronage before the Synod of Perth in 1733 furnished new grounds of accusation, and he was compelled to shield himself from rebuke by appealing to the General Assembly. Here, however, the sentence of the synod was confirmed; and after many fruitless attempts to obtain a fair hearing, he, with Wilson, Moncrief, and Fisher, were suspended from the office of the ministry by the commission in November of that year. Against this sentence the four brethren protested, and constituted themselves into a separate church court, under the name of the Associate Presbytery. It was not, however, till 1739 that they were again summoned before the assembly, when appearing in their corporate capacity they declined the authority of the church, and were deposed in the following year. They received numerous accessions to their communion, and remained in harmony with each other till 1747, when a division took place in regard to the nature of the oath administered to burgesses. Erskine continued to preach to a numerous congregation in Stirling till his death, which took place in 1756. His published works consist chiefly of sermons.

ERSKINE, *Ralph*, brother of the preceding, was born at Monilaws in Northumberland, March 18, 1685. Like Ebenezer he probably studied at Edinburgh, and having been licensed in 1709, he was placed as assistant minister at Dunfermline in 1711. Like him, too, he was a fearless advocate of evangelical opinions, and a stern opponent of ecclesiastical tyranny. This led him to homologate the protests which his brother laid on the table of the assembly, although he did not formally withdraw from the establishment till 1737. He sided with his brother in asserting the lawfulness of oaths administered to burgesses, but did not long survive the rupture which followed that unhappy controversy. He died after a short illness Nov. 6, 1752, being then in the sixty-eighth year of his age. His three sons, who lived to be ministers of the Secession Church, died in the prime of life. The works of Ralph Erskine consist of Sermons, Poetical Paraphrases, and Gospel Sonnets.

ERSKINE, *Thomas, Lord Erskine*, a distinguished lawyer and statesman, was the third and youngest son of David Henry Erskine, tenth earl of Buchan. He was born in Scotland, and received his education partly at the high school of Edinburgh, and partly at the university of St Andrews. From the contracted resources of his family, it was necessary for him to fix upon a profession. He chose the navy, and having embarked at Leith as a midshipman, he quitted his native country, which he did not revisit until a few years before his death. In the navy he experienced no advancement, and, after four years' service, he entered the army in 1768. In 1770 he married, and shortly after this event he accompanied his regiment to Minorca, where he remained during three years. It is not certain whether his abilities as an officer ever rendered him conspicuous, but the versatility of his talents, and the acuteness of his intellect, early gained for him a high reputation. By the earnest persuasion of his mother, who, it would appear, was a woman of more than ordinary penetration, he was induced to quit the army after six years of military probation. The legal profession was the one which appeared best adapted for the character of his mind; and in 1777 he entered as a fellow commoner at Trinity College, Cambridge, for the purpose of obtaining a degree, which he was entitled to as the son of a nobleman, and thereby of shortening his passage to the bar. At the same time he entered himself as a student at Lincoln's Inn. In 1778 he was called to the bar, where his success was both immediate and brilliant. In a case of libel, in which he advocated the cause of Captain Baillie, the defendant, he displayed so much eloquence and talent, that thirty retainers were put into his hand by attorneys before he left the court. A few months after this event he was chosen to appear at the bar of the House of Commons, as counsel against Lord North's bill to restore to the universities the monopoly in almanacks. The bill was lost by a large majority, and the speech which Erskine made upon the occasion so established his reputation for forensic skill, that he was from this period engaged, either on one side or another, in every case of importance, during a practice of twenty-five years. To this period also belongs his famous speech in defence of Lord George Gordon, which procured the acquittal of his client, and proved for the time a death-blow to the tremendous doctrine of constructive treason. In May 1783 he received a silk gown, and the same year was elected member of parliament for Portsmouth, for which borough he was on every election re-chosen, until his advancement to the peerage rendered that honour unnecessary. He was soon after chosen attorney-general by the then Prince of Wales. There is nothing, however, which reflects so much honour on his memory as his exertions in defence of the privileges of juries. The rights of those *pro tempore* judges he strenuously maintained upon all occasions, but especially in the celebrated trial of the Dean of St Asaph, for libel, when Justice Buller refused to receive the verdict of *guilty of publishing only*, as returned by the jury. In 1789 another opportunity was afforded him to display his peculiar powers. This was the defence of Mr Stockdale, a bookseller, who was tried on an information filed by the attorney-general, for publishing what was charged as a libellous pamphlet in favour of Mr Hastings. The situation of the latter, whose celebrated but protracted trial was then dragging its slow length along, gave Erskine admirable scope for that animated appeal to the feelings, by which his speeches are so much distinguished. It is one of his finest orations; and, whether we regard the wonderful skill with which the argument is conducted, the soundness of the principles laid down, and their happy application to the case, the vividness of fancy with which these are illustrated, and the touching language in which they are conveyed, it is justly to be regarded as a consummate specimen of the art of addressing a jury. This masterly defence procured a clear acquittal for Stockdale, although the fact of publication was admitted. Not long afterwards he advocated the cause of Mr Perry, editor of the *Morning Chronicle*, who was also charged with publishing what the jealous loyalty of those times construed into a libel; and his speech produced a similar result. But the most arduous effort of his professional life arose out of the part cast upon him, in conjunction with Mr (afterwards Sir Vicary) Gibbs, in the

trials of Hardy, Tooke, and others, for high treason in 1794. These trials lasted several weeks, and the ability displayed by Mr Erskine upon this memorable occasion was acknowledged and admired by men of all parties. His speech in defence of Mr Frost, which, however, preceded those above mentioned, is another of those almost miraculous exertions, which, in that momentous crisis, Mr Erskine made for the liberties of his country. Frost was accused of uttering seditious words, which, however, turned out to have been spoken at random in a coffee-house whilst the accused was in a state bordering on intoxication. In the violence of that day, the exertions of Erskine failed of their accustomed effect, and Frost was found guilty. But the impression of his defence was not lost; and it deterred the government from risking its credit on such precarious speculations, until, as we have noticed, the charges of high treason were brought forward, when the whole force of the bar was marshalled against the prisoners, and every effort used to beat down and paralyse their undaunted defender.

Erskine was a warm partizan of Fox, and the liberal party of that time. He strenuously opposed the war with France, and published a pamphlet against it, entitled *A View of the Causes and Consequences of the War with France*, which had an immense sale. In 1802 the Prince of Wales not only restored him to his office of attorney-general, of which he had been deprived, but made him keeper of the seals for the duchy of Cornwall. On the death of Pitt in 1806, when Lord Grenville received orders to form a new administration, Erskine was created a peer, by the title of Lord Erskine, of Restormel Castle in Cornwall, and elevated to the dignity of lord high chancellor of Great Britain. His previous experience in the courts of common law scarcely fitted him for the judicial functions of this dignified office; but there seems little doubt that his natural quickness of intellect would have triumphed over every difficulty, had not a dissolution of the administration of which he formed part been accelerated by the obstinacy of the king on the subject of the Catholic claims. His public career may be said to have terminated with this event, and the remainder of his life was undistinguished by any great exertion, whilst it was unhappily embittered by pecuniary difficulties, which were enhanced, it is said, by an unfortunate second marriage. His mind, however, retained its native elasticity, and in his retirement he employed himself in editing several of the state trials. He also wrote the preface to Fox's speeches, a political romance entitled *Armata*, and several pamphlets in support of the Greek cause. Whilst accompanying one of his sons by sea to Edinburgh, he was seized with an inflammation of the chest, which compelled him to land at Scarborough. He reached Scotland by easy stages, but expired on the 17th of November 1823, at the seat of his brother, a few miles from Edinburgh. The peculiar character of Lord Erskine's eloquence has already in some measure been described. In his capacity of advocate he possessed the power of summoning upon the instant all the resources of his mind, and bringing them to bear upon the subject before the court with extraordinary effect. In this respect his speeches bear a resemblance to those of Mr Pitt, whilst they far surpass them in impassioned fervour, in brilliancy of imagination, in copiousness of imagery, and in that quality of mind expressed by the emphatic word genius. His dexterity was likewise unrivalled at the bar; and these qualifications, united with a courage which nothing could daunt, and a firmness which was never overcome, rendered him almost irresistible on the defensive side of political persecution. Amidst all the struggles of the constitution in parliament, in council, and in the field, during that momentous period of our national history, there was no man to whose individual exertions it owed so much as to those of this celebrated advocate.

By his first wife, who died in 1805, Lord Erskine had three sons and five daughters. His speeches have been frequently printed; the last edition is in 5 vols. 8vo. (J. F. S.)

ERUGINOUS (*ærugo, rust of copper*), partaking of the substance or nature of copper, or the rust of copper.

ERYMANTHUS, a lofty and extensive mountain range on the N.W. frontier of Arcadia, which it separated from Achaia and Elis. The highest points of this range are now called Olonos and Kalefoni, the former of which is about 7300 feet above the level of the sea, and the latter about 6250. Erymanthus is famous in the Greek mythology as the haunt of the wild boar whose destruction was one of the labours imposed upon Hercules by Eurystheus. Of the four streams which had their rise in Erymanthus, the Pirus and Selinus flowed northwards into Achaia, the Peneus westwards through Elis, and the cognominal Erymanthus southwards into Arcadia, where, after uniting with the Achelous, it joined the Alpheus.

ERYSIPELAS, or ST ANTHONY'S FIRE, a redness of the skin attended with a sensation of heat or burning, and having a remarkable tendency to spread over the surface of the body. When unattended with constitutional symptoms, it is styled *erythema*. In the three other forms there is more or less constitutional disturbance. These forms are, 1*st*, *Simple erysipelas*, where there is a tendency to the formation of vesicles which break or dry up, leaving the skin either whole or slightly abraded. This form is often erratic, flying from one part of the body to another, lingering about the person for weeks or months. 2*d*, *Phlegmonous erysipelas*, in which the subjacent cellular tissue is involved, and often terminating in the formation of collections of matter, or even sloughing of the tissues. 3*d*, *Œdematous erysipelas*, attended with an effusion of serous fluid below the affected parts, and occurring chiefly in persons of impaired constitutions. In some situations this form is apt to terminate in gangrene. In the great majority of cases of this affection, a brisk purgative followed by tincture of the muriate of iron, fifteen to thirty drops five to ten times daily, combined with belladonna, if the disease has a tendency to spread, rapidly arrests the disease. In the phlegmonous form, hot fomentations of sugar of lead and opium, or of hot whisky and water, afford great relief, though, if matter form, it must be let out by free incisions. The œdematous form requires the more liberal use of iron and quinine, with laxatives and generous diet.

ERYTHRÆ, one of the Ionian cities of Asia Minor, was situated on the sea-coast at about equal distances between the mountains Mimas and Corycus, and directly opposite the island of Chios. Round the town was a rugged and broken territory, in which excellent wine was produced. Erythræ does not seem to have ever attained that power which might have been expected from its position and resources. In the naval battle fought by the Ionian confederates before Miletus, in 494 B.C., the Erythræans had only eight ships engaged, while the Chians had a hundred. They ultimately appear to have owned the supremacy of Athens, but towards the close of the Peloponnesian war they threw off their allegiance to that city. Erythræ was famous as the birth-place of two celebrated prophetesses, one of whom, by name Sibylla, appears to have lived during the early historical period of the city; the other, whose name was Athenais, flourished in the time of Alexander. The site of Erythræ has been accurately ascertained; and considerable remains of its most important public buildings have been discovered at the modern Ritri.

ERYTHRÆUM MARE. See RUBRUM MARE.

ERYX, a city and mountain in the west of Sicily, six miles from Drepana, and a short distance from the seashore. The mountain, now called Monte S. Giuliano, rising to the height of a little more than 2000 feet, appears from its isolation a great deal higher than it really is. On its summit stood a celebrated temple of Venus, called from that

circumstance Erycina, under which name that goddess is frequently mentioned by the Latin poets. The possession of the town of Eryx was contested by the Syracusans and Carthaginians. A great battle was fought off the town between the fleets of the two nations, in which the Syracusans were victorious. The town subsequently changed hands more than once, but it seems to have owned the Carthaginian supremacy at the time of the expedition of Pyrrhus, B.C. 278. Though taken by that monarch, it once more fell into the hands of its original conquerors, who retained it till the close of the first Punic war.

ERZEROUM, or ERZRUM, an important town of Turkish Armenia, and capital of an extensive pashalic of the same name. It is situated in an extensive plain, 6200 feet above the sea, about a mile from the Karasoo or western branch of the Euphrates, and 140 miles S.E. of Trebizond. The town is large but irregularly built, and the streets, like those of all Turkish towns, unpaved, filthy, and infested with dogs. The houses are mostly built of a dark gray volcanic stone, cemented with mud, and strengthened with wood inserted horizontally at certain distances in the walls, which, being rarely plastered, give the town a dull and sombre appearance. Some of the apartments in the larger houses are handsome, and the ceilings of carved wood, gilt, and painted. The roofs are flat, and covered with several feet of earth, which renders them warm in winter and cool in summer, but not impervious to rain and melting snows in the spring. The only exception to this is the custom-house, which has a slanting tiled roof. The town contains twenty-eight khans, thirteen public baths, seventy mosques and mesjids (small mosques or chapels), a Roman Catholic, a Greek, and a large and handsome Armenian church. It is well supplied with excellent water, conducted through wooden pipes from springs issuing from the Palan Duken mountain, to the numerous fountains which are to be found in every part of the town. Towards the south the town is protected by a citadel, surrounded by a double wall flanked with towers and a ditch. The walls, however, are in a state of decay, and could offer but a feeble resistance to an invading force. It is besides commanded by the high hill or mountain called Palan Duken. The principal imports are British and Swiss manufactures, colonial produce, iron, tin, madder root, indigo, and galls. The exports consist of furs, goat and sheep skins, and wool, buffalo hides, wax, tallow, pipe-sticks, copper, and lead. The principal trades carried on are tanning, dyeing morocco (red and yellow), preparing sheepskins for pelisses, making horse shoes and nails, and iron and copper utensils. British manufactures (chiefly cottons) to the value of two millions sterling annually pass through Erzeroum from Trebizond to Persia. The population was estimated in 1854 at 50,000, as follows; Turks 30,000, Orthodox Armenians 5000, Catholic Armenians 2300, Persians 1200, Greeks 300, Russian subjects, consisting principally of Armenians, with a few Georgians and Jews, 1200, and the garrison force then stationed there, 10,000. At the time of the Russian invasion in 1828 it was estimated to contain about 80,000 inhabitants.

ERZGEBIRGE (*Ore Mountains*), a mountain chain of Germany, forming the boundary between Saxony and Bohemia, and extending in a south-western direction from the Elbe to the source of the White Elster, where it is connected with the Fich-tel-gebirge. It is about 120 miles in length, with an average breadth of 30 miles. The southern declivity is generally steep and rugged, while the northern slopes more gradually towards the great plain of Northern Germany. The highest points are Keilberg, 3920, and Fichtelberg, 3835 feet above the level of the sea. This range consists chiefly of granite and gneiss, and is rich in metallic ores of various kinds. Gold is found in several places; while the silver, iron, tin, lead, and cobalt mines are extensive and valuable. Copper is found, but not abundantly, and there is some arsenic, brimstone, vitriol, quicksilver, antimony, bismuth, &c.

ESARHADDON, the son and successor of Sennacherib, king of Assyria. He is the Sacherdon or Sarchedon of Tobit, and the Asaradinus of Ptolemy's Canon. By Hales he is regarded as identical with the first Sardanapalus, and he is generally supposed to be the Asnapper of Ezra (iv. 10).

ESAU, the eldest son of Isaac, from whom the right of inheritance was transferred even before his birth to his brother Jacob. Having sold the actual birthright when on the point of starvation, he was defrauded of the ratification of it by a stratagem of his brother, and instead of being the father of the promised seed he became the head of the Edomites.

ESCALADE, or SCALADE (Lat. *scala, a ladder*), in the military art, an assault on a fortified place, in which ladders are used to pass a ditch or to scale a rampart.

ESCAPEMENT, in *Clock-work*. See CLOCK AND WATCH WORK.

ESCARPMENT (It. *scarpa, a slope*), in military language, ground cut away nearly vertically about a position, in order to render it inaccessible to the enemy. The escarp or scarp of a ditch is that side of it which forms the exterior of the rampart. See FORTIFICATION.

Escarpment is applied in geology to an abrupt or precipitous surface of a rock, hill, or high ridge of land.

ESCARTELED, in *heraldry*, cut or notched in a square form; as a cross.

ESCHALOT (Fr. *échalote*), a small kind of onion or garlic, *Allium ascalonicum*.

ESCHAROTIC, any caustic application; a medicine that sears or destroys flesh.

ESCHEAT, in *Law*, any land or tenement that casually falls to a lord within his manor.

ESCHEVIN, or ECHEVIN, in the French and Dutch polity, a magistrate elected by the inhabitants of a city to manage their common concerns, and promote the good order and decoration of the city.

ESCHWEGE, a town of Hesse-Cassel, province of Lower Hesse, on the Werra, 24 miles E.S.E. of Cassel. Pop. 6050. It is generally well built, and has an old castle, town-hall, hospital, and several Protestant churches. It has manufactures of leather, tobacco, and musical instruments, and some trade by means of the river.

ESCHWEILER, a town of Rhenish Prussia, government of Aix-la-Chapelle, and nine miles E.N.E. of the town of that name. It has manufactures of woollens, silks, needles, wire, &c. Pop. (1849) 3148.

ESCUAGE, or SCUTAGE (Fr. *écu* for *escu*; Lat. *scutum*), in *Feudal Law*, service of the shield; a species of tenure by knight service, by which a tenant was bound at his own expense to follow his lord to war. This kind of service was afterwards commuted for a pecuniary satisfaction. Escuage, together with the other appendages of military tenures, was abolished in England by 12th Car. II. cap. 24.

ESCULENT (*esca*, food), eatable, fit for the food of man; as esculent plants, esculent fish, &c.

ESCURIAL, or ESCORIAL, a monastery and royal palace in Spain, 25 miles N.W. of Madrid, in a country of which the surface is covered with rocks, and where there is little shelter from the winds, which makes this elevated place very cold in the winter months. It was dedicated to St Lawrence by Philip II. on occasion of his having gained the battle of St Quentin, in 1557, on the day sacred to that saint. It is whimsically built in the form of the gridiron on which that saint is said to have been broiled alive. The work was begun by Juan Bautista de Toledo in 1563, and completed by his pupil Juan de Herrera in 1584.

The cross bars of the gridiron are represented by ranges of buildings separated by intervening courts, and which were formerly inhabited by monks and ecclesiastics; but after the sequestration of the convents these buildings were allowed to fall into a dilapidated state, and though some-

thing has been done towards repairing them, they are still untenanted.

The main portion of the building is 740 Spanish feet long, and 580 in breadth. The projection which forms the royal palace is 460 feet in length. The height of the edifice is about sixty feet, and at each angle is a square tower 200 feet high. It is one of the largest, and perhaps one of the most tasteless, buildings in Europe, though grand from its size.

The church, in the centre of this enormous mass of stone, is very large, rich, and of a species of architecture calculated to inspire the mind with awe on entering it. The high altar is most profusely adorned with marbles, agates, and jaspers, and the gold and silver furniture are of the most costly kind. The cupola which covers this church is the most correct object in the whole of the vast pile. The Pantheon, a repositary beneath this church, is the place of interment for the royal family, whose remains are deposited in tombs of marble placed in niches, one above another. The richest part of this edifice, however, was that which contained the valuable pictures to be seen in almost every part of it, and which altogether formed the best collection of the productions of the first masters that any place in Europe displayed. We speak of what it was; for the French, when in possession of the Escurial, removed many of its best treasures, which included the finest productions of Rubens, Titian, Spagnoletto, Raffaelle, Baroccio, Velasquez, Murillo, and others. The most valuable treasures of the Escurial, however, are the immense collection of ancient manuscripts preserved in the library, especially those of the Arabian writers. An account of these will be found under the head LIBRARIES.

There are some good statues, busts, and medallions in the Escurial. The statue of St Lawrence, the patron, is excellent, and said to be an antique; but some of the best of the Spanish artists have averred that the head was from an ancient statue of Bacchus, and the body of more modern workmanship, but nearly approaching in execution to the original portion. These kinds of treasures were, however, less valued by the monks than the autographs and relics of several of the saints, which are preserved here, and exhibited with great veneration.

As this place has been chiefly occupied by the royal family for the sake of the sports of the field, it has been generally inhabited during the autumn and winter months, when, from its exposed situation, it is a most uncomfortable residence. A town has been built near the monastery; but it has never flourished, and has only about 1300 inhabitants.

ESCUTCHEON, or SCUTCHEON (Fr. *escusson;* Lat. *scutum*), the shield on which a coat of arms is emblazoned. Most nations, even from the remotest antiquity, have distinguished their shields by certain devices painted on them; and to be able to display these was a mark of distinction permitted only to such as had performed some honourable action. See HERALDRY.

ESDRAS, BOOKS OF. In several manuscripts of the Latin Vulgate, as well as in all the printed editions anterior to the decree of the Council of Trent, and in many since that period, there will be found four books following each other, entitled the 1st, 2d, 3d, and 4th Books of Ezra. The first two are the canonical Books of Ezra and Nehemiah, the 3d and 4th form the subject of the present article. They are the same which are called 1st and 2d Esdras in the English authorized version of the Apocrypha.

The Third Book of Ezra is found in all the manuscripts of the Seventy, where it is called the *first* book, and precedes the second or canonical Ezra, which, in this version, includes the Book of Nehemiah. It contains 109 κεφαλαια. It is little more than a recapitulation of the history contained in the canonical Ezra, interspersed with some remarkable interpolations, the chief of which are chap. i., taken from 2 Chron. xxxv. xxxvi., part of the last chapter, from Nehem. viii., and the narration of the themes or sentences of Zorobabel and the two other young men of Darius's body-guard (3 Esd. iii. 4). The book is more properly a version than an original work. The style is acknowledged to be elegant, and not unlike that of Symmachus. This book was made use of by Josephus, who cites it largely in his *Antiquities*, but nothing further has been ascertained respecting the age either of the original or the translation. It is cited by Clemens Alexandrinus (*Stromata*, i.), the author of the *Imperfect Work on Matt.* (Hom. i.), Athanasius (*Orat.* iii. *cont. Arianos*), and by Cyprian (*Epist. ad Pompeium*). From the circumstance of Jerome's having declined to translate the third and fourth Books of Ezra, they are (with the exception of the Book of Job and the Psalms) the only portions either of the canonical or apocryphal writings of the Old Testament which have been preserved to us entire in the old Latin translation.

This book does not appear to have been included in the catalogue of any council, nor has any portion of it been read in the offices of the church. Having been rejected as apocryphal by the Council of Trent, it has been removed, together with the fourth book, in the Sixtine and Clementine editions of the Vulgate, to the end of the volume, with the observation that they are thus retained in order to "preserve from being altogether lost books which had been sometimes cited by some of the holy fathers."

The Fourth Book of Ezra is quite of a different character from the third, and it has been even doubted whether it more properly belongs to the Apocrypha of the Old or the New Testament, but the circumstance of the author's personating the celebrated scribe of that name has been supposed to have led to its obtaining a place in the former. It consists of a number of similitudes or visions, resembling in some passages the Apocalypse. The descriptions are acknowledged to be sometimes most spirited and striking, occasionally rising to great sublimity of thought, energy of conception, and elegance of expression (Lee's *Epistolary Discourse;* Laurence's *Æthiopic Version of Ezra*). This would probably be still more apparent had we the book in the original, for it seems highly probable that this, as well as the former book, is a translation from the Hebrew or Chaldee (Morini *Exercit. Bibl.* lib. ii. p. 225; Fabricii *Cod. Pseud. V. T.* iii. 189). But neither this nor the Greek version, which was known to Clemens Alexandrinus in the second century (*Stromata*, iii.), are any longer in existence, and the book was supposed to have been preserved only in the old Latin Ante-Hieronymian Version, until the middle of the seventeenth century, when an Arabic version was discovered in the Bodleian Library by Mr Gregory, a translation of which, by Simon Ockley, the Arabic professor at Cambridge, was published in 1711 by Mr William Whiston (*Primitive Christianity*, vol. iv.) Subsequently an Ethiopic version, which, although known to Ludolf, was concealed from the world, was published for the first time, accompanied by a Latin and English translation, by the late Archbishop Laurence, in 1820. The book is ascribed to the *prophet* Ezra by Clemens Alexandrinus (*Strom.* b. iii.), who looked upon it as canonical and divine, as did Irenæus, Tertullian, and Ambrose, who has made several quotations from this "prophet," as he also styles him (Sixtus Senensis, *Biblioth. Sanct.*), and among others, one which no longer exists in the Latin, but is found both in the Arabic and Æthiopic (Laurence's *Ezra*). Jahn observes that the "Catholics have made many martyrs on its authority" (*Heb. Commonwealth*, b. v.) Pico de Mirandula considered this book as divinely inspired, and Gaspar Zamora placed it in his Concordance between Nehemiah and Maccabees. Among modern writers, Whiston (*Authentic Records*), and others both before and since his time, have considered this book as an inspired composition, and as the genuine pro-

duction of Ezra. (See *Prophecy that hath lain hid above these* 2000 *years; Middle State of the Souls departed; the Prophecies of the Second Book of Esdras,* by Sir John Flover.)

Jahn supposes the author of the Fourth Book of Ezra to have been a Jew educated in Chaldea, who borrowed his style from Daniel, and who, having become a Christian, still retained his reverence for Cabalistic traditions. He places him in the first or early in the second century (see also Vogel's *Commentatio de quarto lib. Esdræ,* Altorf. 1795). Archbishop Laurence, on the other hand (*ut supra*), conceives that the author was a Jew who never changed his creed, and endeavours to destroy the two main arguments in favour of the work having emanated from a Christian: one of these is founded on the remarkable fact that the author speaks of Jesus by name (chap. vii. 28), the other on the circumstance of his being plainly conversant with the Christian Scriptures. As to the former, Dr Laurence appeals to the Ethiopic version, where the text is (not *my Son Jesus,* but) "*my Messiah*" shall be revealed, which is confirmed by the Arabic reading, *my Son Messiah.* The archbishop considers these texts both in the Latin and Arabic to be interpolations or explanatory glosses. The argument derived from the author's acquaintance with the Christian Scriptures is principally founded on the first two chapters, which are wanting in both the Arabic and Ethiopic versions, and in most manuscripts of the Latin are placed at the beginning of the Third Book of Ezra, or at the end of Nehemiah, where they form a distinct book. The last two chapters are equally wanting in these versions, and in most Latin manuscripts form a fifth book, or are otherwise clearly distinguished from the former part of the book. This fifth book is in some manuscripts divided into seven chapters, and the whole of the fourth into thirty-nine. The division into two chapters is erroneously ascribed by Dr Frank Lee to Robert Stephen, for the same division is found in the Editio Princeps by Fust and Schoeffer, printed in 1462, where also the last two chapters, as well as the first two, are incorporated into the rest of the book, and have so continued in all subsequent editions. Dr Laurence concludes from other internal grounds, that the book was written before the Christian era, after the death of Marc Antony, and before the accession of Augustus, or between the 28th and 25th year before Christ.

Dr Lee is strongly of opinion that the author of this book was contemporary with the author of the Book of Enoch, or rather that both these books were written by one and the same author. It does not appear that Josephus was aware of its existence.

ESHER, a village and parish in the county of Surrey, 15 miles S.W. of London. Here is Claremont Palace (built by the celebrated Lord Clive), formerly the residence of the Princess Charlotte, and now occupied by the widow and family of the late king of France. Esher Palace was a residence of Cardinal Wolsey, but of that splendid edifice only the gate-house now remains. Pop. of parish (1851) 1441.

ESK, the name of several rivers in England and Scotland, the principal of which are in Forfarshire and Dumfriesshire. The word is evidently a derivative from the Celtic *uisk,* water.

ESKI-SAGRA, a town of European Turkey, province of Roumelia, pleasantly situated on a declivity, on a tributary of the Zundja, 70 miles N.W. of Adrianople. It has manufactures of carpets, coarse cloth, and leather. The vicinity is highly cultivated, and there are some well frequented hot mineral baths. Pop. estimated at 20,000.

ESNE, or ESNEH, a town of Egypt. See EGYPT.

ESOPHAGUS, the gullet; the canal by which food passes into the stomach. See ANATOMY.

ESOTERIC (Inner) and EXOTERIC (Outer). These words have been much discussed with reference to the Grecian philosophy, and especially to the system of Aristotle. They have also been applied to various other schools, but always enveloped in some kind of obscurity and doubt, which philology has vainly attempted entirely to dissipate. There are particularly three schools of ancient philosophy with respect to which these words have been employed—those of Pythagoras, Plato, and Aristotle.

Little is known with certainty of the school of Pythagoras; but according to the historians of philosophy the adepts of the Pythagorean institution were divided into several classes according to the degree of their attainments; the Esoteric were those who had learnt more completely the doctrines of their master, and were received into the bosom of the society. The Exoteric were the more simple inquirers who waited without till by enduring trials and privations (among others, silence for five years), they were fitted for reception into the inner communion.

In the doctrine of Plato these two words have a meaning different from this. As they are not applied to the disciples but to the opinions of the master, it has been said that Plato had two sets of doctrines, the one to be communicated only to the more intelligent and faithful disciples, the other to be made known to the vulgar. If this were true, it would be a grave charge against the philosophy of the time of Pericles if it had dissembled its true convictions on the great questions which have always occupied the human mind; if the disciple of Socrates, frightened by the punishment of his master, had veiled the truth to give us in his dialogues only a faint and insincere reflection of his philosophic faith. But the admirable dialogues which have come down to us afford irrefragable evidence that Plato as well as his master has concealed nothing, but has given us his entire views in all their fulness and all their depth, and that all the regrets about losses and concealments are perfect chimeras.

Some have thought that the allusion made by Aristotle (*Physica,* lib. iv. c. 2) to the unwritten opinions of Plato, Ἐν τοῖς λεγομένοις ἀγράφοις δόγμασιν, referred to concealed doctrines; but it is much more likely that those unwritten dogmas were those which were but orally communicated, and not found in the dialogues only because they were less important than those which were written. Pythagoras, in the midst of a hostile and barbarous people, held a mysterious and double doctrine; Plato, in the groves of the Academy, taught such as were perfectly accessible to all, and which we now possess in his works. In these it is impossible to distinguish between the esoteric and exoteric.

This distinction is still less applicable to Aristotle than to Plato, although relatively it may appear more so, for Aristotle himself separates his works into exoteric and acroamatic or esoteric. There are many passages in which Aristotle speaks of his exoteric works; and it is in studying these carefully that we may ascertain the true meaning of the word, at least as far as relates to the Peripatetic philosophy. The result of a strict analysis will show that Aristotle never held a concealed doctrine that had any resemblance to that of Pythagoras.

In what sense then is the word *exoteric* in Aristotle to be taken if the exoteric works are not those which were delivered to the profane or vulgar, and the philosophic or acroamatic works those which were confided to the approved disciples? The difference does not refer to the nature of the teaching, much less to the readers, but only to the forms and processes of the expositions.

The exoteric and the philosophic works treat of the same subjects; in the first he only gives the elements that are more superficial and more easily understood by the less intelligent, but for the second he reserves the arguments that are difficult and weighty and most deserving the meditation of the philosopher. This we hold to be the most plausible explanation of the words *exoteric* and *acroamatic* or *esoteric* when used in relation to the Peripatetic philosophy The

words esoteric and exoteric are sometimes applied to the religious sentiment as prevailing at certain times and in various states. It was a necessary result of the position occupied by the ancient world, that in proportion as scientific culture came to be more generally diffused, the opposition noticed by Polybius between the subjective conviction of the individual and the public religion of the state became more strongly marked. The wiser part endeavoured to maintain the popular religion, merely because they recognised in it a necessary means to political ends. Strabo, who lived in the age of Augustus Cæsar, says "The multitude of women and the entire mass of the common people cannot be led to piety by the doctrines of philosophy; to effect this, therefore, superstition is necessary, which may call in the aid of myths and tales of wonder." And Seneca, in his treatise against superstition, writes, "The whole of that vulgar crowd of gods which, for ages past, a Protean superstition has been accumulating, we shall worship so as never to forget that the worship we pay them is due rather to good manners than to their own worth. All such rites the sage will observe because they are commanded by the laws, not because they are pleasing to the gods." It was impossible on any grounds of truth to establish a fellowship of religious interest between the cultivated class and the uneducated; and thus the philosophic class, while outwardly professing devotion to the popular religion, inwardly despised it as a system of superstition.

The Essenes among the Jews mingled the Chaldaic, Parsic, and Platonic doctrines, with an allegorical interpretation of the Old Testament, and it was only those who had undergone a noviciate of three years that were admitted into full communion in the mystical and ascetic rites of the society. The various sections of the Gnostics in the second and third century of the Christian church adopted the same secret mysteries to which the initiated only were admitted. (Brandis *Manuel de l'Histoire de la Philosophie Grecque et Romaine;* Ritter's *History of Philosophy; Dictionnaire des Sciences Philosophiques;* Neander's *History of the Christian Church.*)

ESPALIER (*palus, a stake*), in *Horticulture*, a kind of light frame of wood or iron, resembling a railing, on which fruit-trees and other plants are trained. The term is sometimes extended to the plants thus supported. See HORTICULTURE.

ESPALION, a town of France, capital of a cognominal arrondissement in the department of Aveyron, on the river Lot, 15 miles N.E. of Rodez. Pop. (1851) 4253. It has manufactures of woollen goods and morocco leather.

ESPARTO, a species of rush (*Stipa tenacissima*) which abounds in the south of Spain, where it is manufactured into cordage, nets, matting, baskets, sacks, &c. The light shoes called *alpargates*, so much used by the Spanish peasantry, are made of this material. Cables made of esparto are said to be excellent; and as from their lightness they float on the surface of the water, they are less liable than hempen cables to be cut or injured by a foul bottom. These cables are used exclusively in the Spanish navy.

ESPINEL, VICENTE, a Spanish ecclesiastic, born in 1544 in the province of Granada, who is now chiefly noted as having produced one of the best of those romances delineating Spanish manners, that have found imitators in other countries. This book is entitled *Relaciones de la Vida y Hechos del Escudero Marcos de Olregon*, which appeared in 1618 at Barcelona, at a period when Spanish literature was at a low ebb. Marcos is not a chivalresque *esquire*, but a simple individual who seeks his fortune by attaching himself to great men; and the object of the author is to warn young men against so degrading a course of life. The *squire* tells his own story. The incidents are not generally exciting, though amusing, and nationally characteristic; the style correct, though somewhat diffuse. Its chief interest, like that of the clever *Vida y Hechos del Picaro Gusman de Alfarache* of Aleman, is that Le Sage has not scrupled to borrow from both writers many of the incidents and characters in his admirable novel of *Gil Blas;* a circumstance which has induced an indignant Spaniard to entitle his translation into Spanish of Le Sage's work, *Gil Blas restored to his Country and his Native Tongue*, in the preface to which he denounces the barefaced plagiarism.

Espinel was noted for his musical taste, and added a fifth string to the national guitar. He was also a poet of some reputation, especially for his *Canciones* and *Redondillas.* His pastorals and elegies contain many spirited natural descriptions, though they do not abound in many original conceptions; and his versification is always harmonious.

He also translated into verse some of the odes and the *Ars Poetica* of Horace.

Espinel seems to have been neglected in his old age, for he died in great poverty at Madrid in 1634, at the age of ninety.

ESPLANADE, in *Fortification*, the glacis of the counterscarp, or the slope of the parapet of the covered-way towards the open country; but the term is now most usually applied to the void space between the glacis of a citadel and the first houses of the town.

ESPOUSALS, in *Law*, a contract or mutual promise of marriage. Marriage is termed an espousal *de præsenti.* See MARRIAGE.

ESQUILINE (*Esquiliæ*), the largest of the seven hills of Rome. See ROME.

ESQUIMAUX. See AMERICA.

ESQUIRE (Fr. *éscu*, a shield, from the Lat. *scutum*, from the Gk. σκύτος, *a hide*, with which shields were anciently covered) originally denoted the attendant or shield-bearer of a knight, and hence he was called *escuier* in French, and *scutifer or armiger* in Latin. In the days of chivalry the esquire was second in rank to the knight. Aspirants to knighthood passed through several gradations of service or apprenticeship to arms, as page, and esquire or bachelor, previous to being admitted to that honour. The esquire had several privileges, such as the right of wearing a sword and defensive armour, which last, however, differed from the full panoply of a knight; and he likewise might use heraldic bearings on his escutcheon or shield. There was also another class of esquires, consisting of those tenants by knight's service who had a right to claim knighthood, and who possessed many of its privileges. Such was the German *Ritter*, as distinguished from the *Ritter geschlagen* or dubbed knight.

Respecting the title of esquire in modern times, it is somewhat unsettled, says Blackstone (book i. chap. 12), what now constitutes a right to this distinction, or who is a real esquire; for it is not an estate, however large, that confers this rank upon its owner. In some old writers mention is made of esquires by creation, by investiture with a silver collar of SS., to which ceremony was added the putting on of a pair of silver spurs. It appears that in England this title appertains by right of birth to the following persons: the sons of younger sons of dukes and marquises; the younger sons of earls, viscounts, and barons, and their eldest sons; the eldest sons of baronets and of knights. The following also are reputed esquires: officers of the queen's court and household; officers of the navy and army, down to the captain inclusive; doctors of law; serjeants and counsellors at law; physicians; justices of the peace while in commission; and the sheriffs of counties for life. The heads of many ancient families likewise are deemed esquires by prescription. The title, however, is now usually given to all professional and literary men, and is very generally affixed, as in the superscription of letters, to the names of persons who live in the rank of gentlemen. Hence the distinction it formerly conferred is virtually destroyed.

ESSAYING, or ASSAYING. See ASSAYING.

ESSECK, ESSEG, or ESZEK (Slav. *Oszek*, anc. *Mursia* or *Mursa*), the capital of Slavonia, and one of the most strongly fortified towns in the Austrian dominions, is situated on the right bank of the Drave, 13 miles from its confluence with the Danube. Mursia was founded by the Emperor Hadrian in A.D. 125, and became afterwards the residence of the Roman governors of Lower Pannonia. It was erected into a bishopric by Constantine in 335. The present fortress was erected, upon the site of a previous one, by the Emperor Leopold I., between 1712 and 1719. It is not extensive, but is well constructed, containing many massive buildings, including an arsenal, and barracks capable of accommodating 30,000 men. It is surrounded by a broad esplanade, and is strengthened by works on the opposite side of the river. To the N.W. of it stands the *Ober Varos*, or Upper Town, with which it communicates by an avenue 1100 paces long. On the E. is the *Unter Varos*, or Lower Town, occupying the site of the ancient *Mursia;* while on the W. is the New Town. Esseck has 1 Greek and 5 Roman Catholic churches, 4 chapels, town-house, county hall, Catholic gymnasium, a High and a Greek school, and several monasteries. A long wooden bridge crosses the Drave and the swampy ground on the opposite side of that river. Pop. about 12,500, chiefly employed in the spinning of silk. Esseck is a steam-packet station, and a place of considerable trade in corn, cattle, and raw hides.

ESSEDARII, in *Roman Antiquity*, gladiators who fought in a heavy kind of chariot called *esseda* or *essedum*. The *esseda* (which derived its name from the Celtic word *ess*, signifying a carriage) was a ponderous kind of chariot much used in war by the Gauls, the Belgæ, and the Britons. It differed from the currus in being open before instead of behind; and in this way the owner was enabled to run along the pole, from the extremity of which, or even from the top of the yoke, he discharged his missiles with surprising dexterity. A large body of *essedarii*, by which name the British warriors who drove these chariots were distinguished by the Romans, were taken captive in battle, and occasionally exhibited in the gladiatorial shows at Rome, to the great delight of the people, who beheld with admiration the feats performed by these bold and skilful charioteers. (Cæs. *Bell. Gall.* iv., v.; Tacit. *Agric.* xii.; Suet. *Calig. Claud.;* Cic. *Fam.* vii.)

The Romans applied the same name to a light carriage of similar construction, which was drawn by a pair of horses, and adapted for convenience and luxury. It probably differed little from the *covinus*, except that the latter was closed overhead.

ESSEN, a town of Rhenish Prussia, government of Düsseldorf, on the Berne, and near the Cologne and Minden Railway, 20 miles N.E. of Düsseldorf. Pop. (1849) 8813. It is surrounded by walls; is the seat of a mining board and a municipal court of justice; and has several Protestant and Roman Catholic churches, an old Capuchin convent, a gymnasium, hospital, and orphan asylum. The town is thriving, and has manufactures of woollen and linen goods, fire-arms, steam-engines, iron and steel wares, leather, and vitriol. In the vicinity are some valuable coal mines.

ESSENCE (from *esse, to be*), that which constitutes the particular nature of a being or substance, or of a genus, and which distinguishes it from all others. Locke makes a distinction between *nominal* and *real* essence. The nominal essence, for example, of gold, is that complex idea expressed by gold; and its real essence is the constitution of its insensible parts, on which its properties depend, and which is unknown to us.

Essence is also used to denote the predominant qualities of any plant or drug extracted, refined, or rectified from grosser matter; or, more strictly, a volatile essential oil.

ESSENCE D'ORIENT, a pearly-looking substance, employed in the manufacture of artificial pearls. It is procured chiefly from the scales of the blay or bleak, a fish of the genus *Cyprinus*, and is prepared by the simple process of steeping the scales in water, and rubbing them with the hands until the glistening matter is separated. This is again washed, and then thrown upon a sieve, that the moisture may drain off. This substance, while in a viscid state, readily putrefies; but this tendency may be counteracted by liquor ammoniæ, which coagulates the mucilaginous matter.

ESSENES, one of the three great Jewish sects, of which the other two were the Pharisees and the Sadducees. The derivation of the name Essenes is by no means certain. Philo deduces it from ὅσιος, "holy;" others find its origin in the Chaldee word "to heal" while others give the preference to a Syriac word signifying "pious." These sects sprung up in the decline of the Jewish state, after the Babylonish captivity, and were influenced in their rise and spread not less by ascetic philosophy than by the national degradation and the decay of morality.

While the Pharisees gave their countenance to sustain the past indiscriminately, and the Sadducees rejected all that was traditionary and adventitious, the Essenes sought to originate a moral influence, a moral and religious order; while the Pharisees partook more of the character of a political party, and the Sadducees exhibited not a few of the features of a sect.

The Essenes were ascetics, and rejected marriage along with the ordinary social pleasures of life. To recruit their ranks they selected the most promising of the children of others. Riches, too, they held in contempt, and whatever they had they were ready to share with others. Every newcomer put his property, whatever it was, into the common stock; whence his wants were afterwards gratuitously supplied. When they entered any strange city, their brethren received and entertained them as if they had come to their own property; and, in order that travellers might not suffer want or disappointment, there was in every city one of the brethren, who was specially charged to provide them with food, clothing, and other necessaries. These duties of hospitality, however, could not have been onerous, if, as Josephus states, the Essenes did not change their shoes or garments till they were worn out and tattered.

The account which Josephus has given of their pious exercises, and of their daily engagements, is striking and characteristic. Rising before the sun, they abstained from all ordinary conversation, and put up their ancestral prayers, not forgetting to beg for a renewal of the light of day. Then, under the supervision of curators or foremen, they laboured diligently till eleven o'clock in the forenoon, when, assembling together, and being covered with white veils, they bathed in cold water. After thus entering their refectory with certain religious solemnities, they quietly seated themselves, each receiving a loaf of bread and a single plate of one sort of food, and a priest having invoked the divine blessing, they proceeded to take refreshment. When the repast was over, the same priest made an offering of thanks to the great Benefactor of the world, and the brethren all returned to their several employments. These being terminated, in the evening another meal with similar observances was partaken of by all in common.

Next to God, Moses was the object of their reverent homage; and to blaspheme his name was a capital offence. In their reverence for the sabbath they would neither cook their food on that day nor remove a vessel from its place, even for the most pressing wants of nature. At set times they frequented the sacred places called synagogues, where the young sat arranged in classes according to age, under the eye of their elders. Here one took and read, and another expounded, the sacred books. A system of allegorical interpretation prevailed. Among their instructions the virtues of holiness, justice, and economy, held a prominent place;

nor did they omit the duties which men owe to the state. Their teachings were accompanied by definitions and rules, and were enforced by a regard to the love of virtue, the love of man, and the love of God.

According to Josephus, they regarded the body as frail and corruptible, but the soul as living for ever. Asceticism was the necessary result of their conviction that souls came out of the most subtle air, from the loftiest empyræum, and are lodged in bodies as in prisons, from which, when once set free, they rejoice and soar away to their native regions. Of the predictions which Josephus alleges the Essenes to have made, from the study of the sacred writings, and the frequent use of purifications, it would have been wonderful if some had not proved true; for the accomplishment of others, they had the machinery in their own hands.

Their pursuits, trades, and professions were such as conduce to human good. They tilled the ground; they made useful articles; they bred and pastured cattle; but in the fabrication of arms they took no part. Even peaceful pursuits which ministered to vice they carefully avoided. It must not be concealed, however, that some of their notions bordered on extravagance, and that some of their practices betrayed a fastidiousness which bordered on the ridiculous. In morals they seem to have attained no ordinary excellence. Over anger they kept a guard like just stewards. All the passions they knew how to restrain. They were eminent for fidelity, and ministers of peace. Their word was more to be trusted than some men's oaths. Swearing, indeed, they studiously avoided; alleging with no small reason, that the man is already condemned who cannot be believed without an oath.

Admission into their communities was obtained only after a noviciate of twelve months, when those who were approved were habited in white, and received a girdle and a sort of small hatchet, being made "partakers of the waters of purification"—that is, probably, baptized. A further probation of two years was then undergone. When admitted into the society, the neophyte bound himself by vows or oaths to exercise piety towards God and justice towards men; to hate the bad and assist the good; to harm no one, either of his own accord or by the command of others; to be faithful to all men, especially to such as are in authority; to love truth and reprove the liar; to keep his hands clean from theft, and his soul pure from unlawful gain; to conceal nothing from the brotherhood, and reveal to others none of their secrets, not even should life thereby be put in peril; to transmit the Essene doctrines unchanged to others; to preserve their books and the names of their officers (ἄγγελοι, angels) in strict secrecy. The newly-admitted brethren were distributed among four classes; and the gradations of age were so rigidly observed, that if a senior touched a junior brother, the first had to undergo a purification by water, as if he had been in contact with a foreigner. The Essenes did not offer oblations in the Temple at Jerusalem, though they sometimes sent presents thither A pure heart they held to be the best offering. Religious ablutions they considered acts of holiness. They did not admit logic among their studies, and metaphysics they avoided, as relating to subjects which are too high for man; yet they made an exception in favour of those branches which refer to the existence of God and the creation of the world. Morality —the morality which they by their own process learnt from Moses—was the chief object of their studious care.

Pain they disregarded; the miseries of life they held of small account; and they even preferred death to living always. The calm and unmoved firmness with which they endured at the hands of the Romans, during "the Jewish war," the cruellest tortures, and death itself, rather than be faithless to their convictions or forswear their order, serves to show that the ascetic spirit and the martyr spirit have no little in common, and exhibits within the limits of Palestine the very same results, from the very same discipline, as Sparta was proud to call her own.

Josephus mentions another kind of Essenes, who entertained less unfavourable opinions of female virtue and honour, and who, holding that marriage was a divine ordinance for the propagation of the human species, did not think themselves justified in condemning or avoiding it. They, however, used the precaution of giving those females whom they thought of marrying a trial for three years, at the expiration of which they actually married them, provided they were satisfied, merely as a duty, and accordingly did not neglect the same ascetic principles which characterize the whole of the Essene life.

In the account which has now been given we have followed in the main the authority of Josephus and Philo. The latter speaks of a species of Essenes under the name of Therapeutæ, whom we shall notice under that head, contenting ourselves at present with remarking that, in regard to the institutions and practices of the Essenes generally, it is probable that a good deal of the warm colouring of the picture, if not some of its objects, may have been borrowed from the imagination of the artists by whom it was originally drawn. Besides Josephus and Philo, the reader may consult Stäudlin, *Sittenlehre Jesu*, Gotting. 1799; De Wette, *Sittenlehre*, Berlin, 1833; De Wette, *Archäologie*, Leipzig, 1830.

ESSENTIAL, necessary to the constitution or existence of a thing. Thus the primary qualities of bodies, such as extension, figure, number, and so on, are essential or inseparable from them in all their changes and alterations.

ESSENTIAL OILS, or VOLATILE OILS, are mostly obtained from odoriferous vegetable substances, although some of the principles are found in animal matters. They are usually obtained by distillation, but in some instances by simple expression. They differ much in their physical properties. The greater number are yellow, others are colourless, while some again are red, brown, or green, and some few are bluish. Instead of being greasy to the touch, like fat oils, on evaporation they leave the skin dry and hard. Among the principal of the essential or volatile oils, are those of turpentine, aniseed, lavender, nutmeg, cloves, caraway, peppermint, spearmint, sassafras, camomile, and citron. See OILS.

ESSEQUIBO, the principal river of British Guiana, South America. This is also the name of a county through which the river flows. See GUIANA.

ESSEX, a county of England, is bounded on the south by the river Thames, on the east by the German Ocean, on the north by the counties of Suffolk and Cambridge, and on the west by Hertfordshire and Middlesex. Its surface contains 1657 square miles, or 1,060,549 acres. The population has not increased in this county at the same rapid rate as that of some other counties of England.

In 1851 the inhabitants numbered 369,318, being an increase of 62 per cent. in fifty years. The number of inhabitants to a square mile was 222; to a house, 5. The total number of houses was 77,470; 73,530 being inhabited, 3569 uninhabited, and 381 building.

Essex may be considered as a mere agricultural county; for though, from the near approach of one part of it to the metropolis of the kingdom, there are some manufactories established, which find both their raw materials and their consumption in London; and though in one district of the county there are remains of the once extensive manufactories which were brought from Flanders to this island; the number of persons occupied in them bears but a very small proportion to that part of the population which depends on agriculture. The former manufactures of Colchester baizes for the Spanish and American markets have wholly disappeared, and those for woollen goods at Bocking, Halsted, and Coggeshall, are nearly extinct; all having removed to the northern parts of the kingdom. Crapes are manufac-

tured at Braintree, Bocking, and other places; silk, principally for umbrellas, at Colchester and Coggeshall, and satin velvet at Halstead. 2227 hands were employed in the silk trade in 1847. On the eastern side of the county, in the vicinity of the metropolis, are several large distilleries, and some establishments for bleaching and printing calicoes. There are also manufactories of sal-ammoniac, of Prussian blue, of iron liquor for calico-printers, and some other chemical preparations. There is a considerable trade in corn, and much barley is malted for the great breweries and distilleries. The only other commerce is that of supplying the inhabitants with foreign and domestic articles of luxury.

Although nearly half the county is bounded by the sea, or by navigable rivers, it carries on no foreign commerce; and such vessels as belong to it are employed either in conveying to London the produce of its agriculture, or in the oyster fishery, which occupies a considerable tonnage and many seafaring persons. The oysters are bred both in the river Coln and in the Crouch: in the former they are protected by the seignorial rights of the corporation of Colchester, and in the latter by the proprietor of that river, Sir Henry Mildmay. The spawn is deposited in the months of April and May; and it is said the shell about it begins to form within twenty-four hours. The fishermen are forbidden to dredge for them at this season. In the month of July the dredgers separate the small oysters from the stones on which the spawn was deposited, and on which they have grown, and lay them down in the channels of the river till they grow of a size fit for consumption, which is determined by a gage kept for that purpose by the water-bailiff of Colchester. The stones or other substances to which the young oysters had adhered are again thrown into the water whence they were taken, as it is apprehended the accumulation of the ouse at the bottom of the river would otherwise generate such an increase of mussels and cockles as would destroy the breed of oysters. The oyster trade employs about 200 boats and 500 hands. About 15,000 bushels are annually taken. The larger description of vessels are employed during part of the year on the shores of Hampshire and Dorsetshire in dredging for the native oysters, which are afterwards deposited in the beds of Essex and Kent, in order to fatten for the London market. The uncertain produce of the breeding grounds in Essex makes it necessary to have recourse to the more distant coasts to obtain the requisite supply.

From being almost wholly an agricultural county, the far greater part of the inhabitants of Essex are found in villages.

The face of the county is generally very beautiful; it is well inclosed, and for the most part displays good verdant pastures; the hills, none of which rise to great heights, are cultivated to the tops; and there is abundance of trees, especially oak and chestnut, which give a rich appearance to the view. There is no county in England in which the proportion of waste land is so small. The forests and wastes can indeed scarcely be considered as utterly uncultivated, and the whole of them do not amount to more than 14,000 acres, including the two forests of Epping and Hainault. These belong to the crown, though the inhabitants of many surrounding parishes have the right of pasturing their cattle upon them. The sovereign has an unlimited right to keep deer on all the inclosed woods; and the occupiers of land in the various parishes included within the ancient boundaries of the forests have a right to feed horses and cows, but not other cattle. The numerous common rights have led to considerable devastation of the timber of these forests, and occasioned no small injury to the property of the crown; but plans have been adopted for preserving the trees, and converting a part into a nursery for growing timber for the royal navy. Their vicinity to the sea makes these forests well deserving of being appropriated to this purpose.

That part of Essex which lies on the banks of the Thames, and on the shores of the ocean, is a rich alluvial soil on a subsoil of very tenacious clay. It produces, with good cultivation, very abundant crops of wheat, beans, oats, and clover. It is found necessary to the cultivation to fallow very frequently, and repeated ploughings are very generally adopted. The swing plough is much used, and sometimes a wheel plough drawn by two, and occasionally by three horses abreast, which are guided with long reins by the ploughman. In fallowing it is common to plough the land six or seven times, and it is not unusual with the best cultivators to plough it eight or even ten times. After the summer fallow, by which the soil becomes completely pulverized, and rendered as fine as a garden, it is sometimes the practice to sow wheat in the autumn; but it is more common to let it remain throughout the winter, and then, after a spring ploughing, to sow barley or oats. The rotation of crops which usually succeed to a fallow is, 1. barley or oats; 2. clover, red or white, mostly the former; 3. wheat; 4. beans, twice hoed at least; 5. wheat. After this course the land is again fallowed. The whole produce of the course of crops is said to depend on the accuracy and skill exercised in the process of fallowing.

There is in this district some land adapted for turnips, and the rotation on such soils is usually, 1. turnips; 2. oats or barley; 3. clover; 4. wheat; 5. beans; 6. wheat. These courses are occasionally varied, tares being introduced when the clover fails, and peas being sometimes substituted for beans. The best cultivators often omit the second crop of wheat, and fallow again after the beans. A rotation which is sanctioned by some very skilful agriculturists is the following:—1. fallow; 2. barley or oats; 3. clover; 4. beans; 5. wheat; 6. tares or peas; 7. wheat. In this case the manure is laid on the clover ley for the bean crop. In the district we are describing all the farms have a portion, more or less extensive, of rich marsh land, on which oxen are fed, and which supplies hay for winter consumption, and is consequently the source whence the manure is derived. The best wheat that is brought to the market of the metropolis is raised in the part of Essex of which we are speaking, and which is usually denominated the *hundreds*. It has the convenience of water-carriage to London; the rent of the land, which is of extraordinary fertility, is comparatively low; but the want of good water is sometimes severely felt. Much has of late been done to improve the internal condition of the county, but its unhealthiness, from the prevalence of ague, especially in autumn, and the badness of the roads, still continue to prevent many of the gentry from residing on their estates.

The middle part of Essex rises above the level of the marshy lands, but partakes in a considerable degree of their unhealthiness. Around the town of Colchester, for a considerable distance, the soil is a dry loam, well calculated for turnips; and then the most general system adopted is the four-course husbandry of Norfolk, viz., turnip, barley, clover, and wheat. A variation is in some instances introduced by taking a crop of peas after the wheat, and occasionally tares are sown after the barley instead of clover, as that latter plant will sometimes fail if too frequently repeated. The greater part of the district is, however, of a clayey loam, on a subsoil of clay, and too tenacious for the turnip system. Much of this is good old pasture land, used solely for feeding, and to which the plough is never applied. The arable land is highly productive; the crops of wheat and beans especially are very luxuriant, and their produce of the best quality. The practice of fallowing is pursued as in the district before described, but so many ploughings are not deemed necessary. The rotation is various, but it rarely occurs that wheat is sown immediately after the fallow. Most commonly the succession is as follows:—1. fallow; 2. barley; 3. beans; 4. wheat; 5. tares; 6. barley; 7. clover. When the land is more wet, which, in spite of excellent draining, is frequently the case, the rotation is, 1. fallow; 2.

oats; 3. clover; 4. wheat. When manure is abundant, the heavy soils are cropped in the following rotation with great success: 1. fallow; 2 beans; 3. wheat; 4. tares; 5. barley; 6. clover; 7. beans; 8. wheat. In this rotation the clearing of the ground from weeds depends on the use of the hoe, which is applied most carefully to the crops of beans.

The western part of the county, especially where it borders on Hertfordshire, is, in general, land of a very inferior quality, and, without very expensive cultivation, yields but light crops. In one extensive district, called the Rodings, is still practised a most singular system of husbandry, known now in Essex only, though formerly it was adopted on poor lands in some other counties. It is, 1. a year's fallow; 2. wheat; 3. fallow; 4. barley, and then a repetition of the same course; thus having one-half the arable land constantly without any crop. The soil is a tenacious clay, of a reddish colour, upon a subsoil of white clay. It is difficult to pulverize, and, with wet, potches so much as not to admit of ploughing when the atmosphere is moist. There are but small parts of this district which produce clover, peas, tares, or beans; and hay is only grown on the narrow borders of the rivulets which run in the valleys.

In the south-western part of the county the agriculture assumes that system which is adapted to the supply of the wants of the metropolis. A great portion of the land is in permanent pasture, or grows hay to furnish the markets of Smithfield and Whitechapel. The arable land is generally cultivated with a rotation of three crops, viz., potatoes, wheat, and clover; and as London supplies abundance of manure, by applying it very liberally to the young clover after the wheat is harvested, most abundant crops are the consequence, and the land is cleaned by the potato culture. In this kind of husbandry, which, indeed, can only be conducted where manure is to be obtained with great facility, the plough is only used once in the rotation after the clover; for as the potatoes are planted, the digging them up sufficiently prepares the land for wheat.

The farms vary much in size, but average from 150 to 200 acres. They are sometimes held on lease for seven or fourteen years, but more generally from year to year. Wheat averages 20 to 30 bushels to the acre; barley 40, oats 12 quarters, beans 32 bushels, and potatoes 300 bushels. Teasel, caraway, and coriander, are grown together in spring. The coriander is cropped in autumn, the caraway in July of the succeeding year, and the teasels in September of the same year. Hops, saffron, and mustard, are also grown in a few localities.

Essex feeds some sheep, but very few are bred in the county. The stock of sheep, principally Southdowns, is about 520,000, producing annually 8650 packs of wool. Calves are suckled to a great extent, and the rearing of them to furnish veal for the London market is the principal source of income to many farmers. The whiteness of the veal is produced by a great attention to cleanliness, by regular periods of suckling, and by giving the calves a small portion of barley-meal mixed with chalk. The tendency to fatten is promoted by administering narcotic drugs, which keep the young animals in a quiescent state. Though the county affords such abundance of excellent pasture, yet the fattening of calves is so much more profitable than the dairy, that it is supplied with butter from other counties. Epping has indeed been celebrated for its excellent butter; but the greater part of what is sold in London under that denomination is the produce of Northamptonshire, Buckinghamshire, and other counties. The Epping dairies produce 212 pounds of butter per cow annually. London is supplied with much of its beef from Essex. The bullocks, in a lean state, are brought from Scotland, from Wales, and some from Devonshire, and are fattened in this county, sometimes on the rich natural meadows, and sometimes on turnips with the addition of oil-cake.

The landed property in Essex, as in other counties near the metropolis, is very much divided; there are no overgrown estates, though some of considerable value, belonging to a few individuals; but the greater part is in moderate-sized farms, which can be easily disposed of, and which are frequently purchased from the savings of the commercial class in London.

The only good harbour in this county is Harwich, whence the packets for Holland are despatched, and where there is a royal dock-yard, in which some frigates are built and repaired. The river Coln is navigable for small vessels to Colchester, and the Blackwater river to Walden. The Crouch is navigable for the largest ships; but, passing through an unhealthy country, and having few inhabitants on its borders, it is useless for the purposes of commerce. The river Lea is navigable by barges a distance of 25 miles. There are no canals in this county, but one is projected to unite the river Lea with the Cam, and thus create internal navigation from Lynn to London.

The county is divided into two almost equal portions by the London and Eastern Counties Railway, from which are a few branches. The London and Cambridge line skirts the western boundary.

The county gives the titles Earl of Essex to the Cassel family, and Lord Colchester to the Abbots.

The members of the House of Commons elected in Essex are ten, being two for each of the boroughs of Colchester, Harwich, and Maldon, and four for the county, which, for election purposes, has been divided into the northern and southern districts. The polling places of the former are Braintree, Colchester, Saffron-Walden, and Thorpe; and of the latter, Chelmsford, Billericay, Romford, Epping, Rochford, and Maldon.

The most remarkable seats of noblemen and others are Audley-End, Lord Braybrooke; Thorndon, Lord Petre; Easton Lodge, Lord Maynard; Navestock, Earl Waldegrave; Mistley Hall, Lord Rivers; Dagenham Park, Sir Thomas Neave; the Hyde, —— Disney, Esq.; Hill Hall, Sir E. Smith, Bart.; Weald Hall, Christopher Tower, Esq.; Boreham House, Sir John Tyrell, Bart., M.P.; Coped Hall, —— Conyers, Esq.; Mark Hall, —— Honeywood, Esq.

The antiquities of the county consist of British camps at six distant places, including Ruckolt, Bartlow Hills, and Lexden Heath; Roman camps at Witham, Colchester, and other places, and a number of Saxon remains. Some remains of castles are still extant, among which the most interesting, at least historically, is Pleshy, once the seat of the "Good Duke Humphrey."

Hainault Forest was once famous as the hunting ground of Queen Elizabeth, who by her noted speech at Tilbury rendered that fort famous in history; and Colchester for its stout defence when besieged by Fairfax in 1648. Tusser the agricultural poet, Ray the naturalist, Bishop Bedell, and Quarles the poet, were natives of the county.

Essex, the name of several towns in the United States, the principal of which is in the state of New York, on the W. side of lake Champlain, 108 miles N. by E. of Albany. Pop. (1850) 2351. There are also several counties in the United States of this name.

ESSLING, a village of Austria. See Aspern.

ESSLINGEN, a town of Würtemberg, circle of Neckar, on a river of that name, 7 miles N.E. of Stuttgart. Pop. about 7000. The town is very ancient, and previous to 1803 was one of the free cities of the German empire. It is surrounded by walls, and has five suburbs, one of which stands on an island in the river. On a commanding height above the town stands an old castle. The church of Our Lady is a Gothic edifice built in 1440, and has a tower 230 feet high. The town-hall is a handsome building. Esslingen has a richly endowed hospital, an orphan asylum, and a normal and other schools. The manufactures include

woollen and cotton stuffs, and hardware. In the vicinity are numerous vineyards producing a sparkling wine known as Neckar champagne.

ESTAFETTE, a military courier.

ESTATE, in *Law*, signifies the title or interest which a person has in lands, tenements, or other effects. Estates are *real* or *personal*. *Real* estate, called also *heritable* estate, consists generally in things immoveable, as lands, houses, &c., or in rights secured on these. *Personal* or *moveable* estate consists generally in things moveable, as money, household-furniture, ships, &c.

ESTATES, in a political sense, a term used to denote either the dominions of a prince, or the several classes of men in a society or government.

In Great Britain the estates of the realm are the sovereign, lords, and commons; or rather the lords and commons, who meet the sovereign in parliament, for the purpose of reforming abuses and enacting laws.

ESTE, the ancient *Ateste*, a town of Lombardy, delegation of Padua, 18 miles S.S.W. of the town of that name. It is picturesquely situated at the foot of the Euganean hills, on the canal of Monselice. Most of the houses are supported by arches. The exterior of the church of San Martino bears the appearance of high Romanesque antiquity, but the interior is modernized. There is a leaning tower in the same Romanesque style. The Rocca or castle near the town is a fine and almost perfect building, standing on the site of the original fortress, the seat of the celebrated family of Este. The more immediate founder of this family was Alberto Azzo, born in 996, from whom the sovereigns of Great Britain, Hanover, Brunswick, and Modena are descended. Pop. about 9000, employed in manufactures of silk twist, hats, linens, and earthenware.

ESTELLA, a town of Spain, province of Navarre, on the Ega, 25 miles S.W. of Pamplona. It has an old castle, a college, several brandy distilleries, and manufactories of woollen cloths. Pop. 5342. It was long the headquarters of Don Carlos, who was proclaimed king here in 1833.

ESTEPONA, a maritime town of Spain, in the province of Granada, on the Mediterranean, 25 miles E.N.E. of Gibraltar. It carries on an active fishing and coasting trade. The manufactures are chiefly linen, leather, earthenware and bricks. The vicinity is very fertile, producing oranges, lemons, and other fruits, which are largely exported to England. Pop. 9383.

ESTERHAZY or ESTERHAZ, a village of Lower Hungary, county of Oldenburg, near the S.E. extremity of Lake Neusiedl, 40 miles W.S.W. of Presburg. Here, surrounded by gardens and a noble park, stands a magnificent palace of Prince Esterhazy, now unoccupied. It is in the florid Italian style, and is surrounded by a gallery adorned with statues and vases. Its marble halls brilliant with gold and painting are still fresh as when new.

ESTHER, BOOK OF, one of the eleven books styled *Ketubim*, and of the five *Megilloth*. It is called by the Jews *Megillah Esther*, and sometimes simply *Megillah*, as it forms by itself a distinct roll. In the Christian Church it has been also called *Ahasuerus*, which name it bears in some copies and printed editions of the Vulgate. In the Hebrew it is placed with the other *Megilloth*, after the Pentateuch, between the Books of Joshua and Ecclesiastes, and sometimes among the *Hagiographa*, between Ecclesiastes and Daniel. In the Vulgate, Tobit and Judith are placed between Nehemiah and Esther. Luther placed it immediately after Nehemiah to prevent the books of Nehemiah and Ezra from being disunited. It has continued to retain this position in the Reformed versions.

The principal historical difficulty of this book has been the solution of the question—What king of Persia is meant by Ahasuerus? For there has been no Persian monarch from Astyages, who died B.C. 603, and his son Cyaxares, to Darius Ochus, who died B.C. 358, or his son who died 20 years later, who has not been maintained to be the husband of Esther. Those who have most suffrages are Darius Hystaspis, Xerxes, and Artaxerxes Longimanus; for which last monarch we have the authority of Josephus and of the Septuagint Version, wherein he is called by the name of Artaxerxes. Jahn coincides with the view of Scaliger, who supposes that Amestris, the cruel and vindictive wife of Xerxes, is no other than Esther, as both the name and the character of Amestris favour the supposition that she is the Esther of the Bible. But she is said by Herodotus to have been the daughter of Otanes, a *Persian*, and to have been married to Xerxes before his Grecian expedition. Bellarmine, who adopts the view of Josephus, is not affected by the circumstance that, in this case, Mordecai's age must have exceeded 165 years, as he himself had known "a hale old man of 105, who was likely to live still many years." Of the true historical character of the book the existence of the feast of Darius furnishes a sufficient attestation. Of the authorship of Esther nothing is known, nor have we any data on which to form a reasonable conjecture. Augustine ascribes the book to Ezra. Eusebius ascribes it to some later but unknown author. Clemens Alexandrinus assigns it, and the Book of Maccabees, to Mordecai. The pseudo-Philo and Rabbi Azarias maintain that it was written at the desire of Mordecai by Jehoiakim, son of Joshua, who was high priest in the 12th year of the reign of Artaxerxes. De Wette assigns it to the age of the Ptolemies and Seleucidæ, whose era commenced B.C. 312; while Jahn maintains that it must have been written soon after the facts which it records, and before the destruction of the Persian monarchy (B.C. 330), to whose annals it appeals.

Various attempts have been made to assign to the Book of Esther only a deutero-canonical character, partly from its being unquoted in the New Testament, and partly from its being omitted in the catalogues of Melito and other writers. The former objection, however, would hold true of many other books which are yet of undoubted authority; and the latter is met to a large extent by the consideration that the Book of Esther is included under the books of Ezra. Against this slender evidence there is a large mass of positive authority which it is needless to adduce at any length. The hostility of Luther to this part of the Old Testament on account of its Judaism and "heathenish naughtiness," is considerably palliated, if, as seems probable, he referred to the whole book with its apocryphal additions. These he removed to a separate place among the apocrypha; and though they have been placed authoritatively in the canon by the council of Trent, it is certain that they were as ignominiously treated by the fathers as by Luther.

ESTHETICS. See ÆSTHETICS.

ESTHONIA or ESTLAND, one of the Baltic provinces of Russia, lying between N. Lat. 58. 20. and 59. 30., and between E. Long. 23. 20. and 28. 20. It is bounded on the N. by the Gulf of Finland, W. by the Baltic, S. by Livonia and Lake Peipus, and E. by the province of St Petersburg. It comprises the islands of Dago, Worms, &c., and a portion of Lake Peipus; and has a total area of 7966 square miles. Estimated population (1846) 310,400. The surface is generally flat, occasionally diversified with undulating hills. The soil is mostly sandy, and a great part of it is occupied by swamps and morasses. It has numerous streams, but the only river of importance is the Narva, which flows northward from Lake Peipus to the Baltic, and forms the boundary between this province and that of St Petersburg. The climate is cold and moist. The winters are long, extending from the end of October to May, and fogs and violent winds are common throughout the year. Not above one-third of the province is under cultivation; but the chief occupation of the inhabitants being agriculture, the corn produced is more than sufficient for home con-

sumption, the surplus being used for making spirits. Besides rye, barley, and oats, it produces wheat, maize, hemp, flax, hops, and tobacco. Several species of pulse are extensively cultivated, and form a large proportion of the nourishment of the peasantry. The forests are extensive, and include fir, pine, elm, birch, larch, beech, oak, &c. The province possesses large meadows and good grazing grounds: next to agriculture the rearing of cattle engrosses the chief attention of the inhabitants. The horses and horned cattle are small. Sheep, goats, swine, and poultry, are reared in great numbers. Of the wild animals, the bear, wolf, fox, badger, and lynx, are the most common; some elks are also found. The fisheries along the coast are very productive. The manufactures are few and unimportant, being mostly domestic. There are numerous distilleries, and the inhabitants, according to ancient usage, enjoy the right of working them without government license. The chief town is Revel. This country was sold by the Danes to the Teutonic knights in 1346, and became a province of Sweden in 1560. In 1710 it was wrested from the Swedes by Peter the Great.

ESTOILEE, or Cross Estoilée, in *Heraldry*, a star with only four long rays in the form of a cross, broad in the centre, and terminating in sharp points.

ESTOPPEL (Fr. *estouper*, to stop), in *Law*, an impediment or bar of action, arising from a man's own act or deed.

ESTREMADURA, a province of Spain, lying between N. Lat. 37. 58. and 40. 32., and between W. Long. 4. 32. and 7. 26., being about 180 miles in length from N. to S., by 130 in extreme breadth, and having an area of about 14,280 square miles. It is bounded on the N. by Salamanca and Avila, E. by Toledo and La Mancha, S. by Cordova and Sevilla, and on the W. by Portugal. The name is said to be derived from the Latin *extrema ora*, as it was the extreme conquest of Alonso XI. from the Moors in 1228. The Tagus and the Guadiana cross this province from E. to W., and their respective basins form two natural and nearly equal divisions; that of the Tagus, being the northern, called Alta or Upper Estremadura, and that of the Guadiana, Baja or Lower Estremadura. These two basins are separated from each other by a range of mountains, of which the eastern and highest portion attains an elevation of from 5000 to 6000 feet above the level of the sea. This natural division corresponds to the division into the new provinces of Badajoz and Caceres, the former being Baja Estremadura, and the latter Alta Estremadura. These contained in 1849 respectively 336,136 and 264,988 inhabitants. The basin of the Guadiana is bounded on the S. by a continuation of the Sierra Morena, which fills up the southern part of the province with hilly ground, and divides the waters of the Guadiana from those of the Guadalquivir. A branch of this chain proceeds northward from the confines of Cordova to the Guadiana. The basin of the Tagus is bounded on the N. by a range of mountains which proceed westward from Avila along the boundaries between Estremadura and Salamanca, and afterwards enter Portugal. From this northern range a branch proceeds in a S.W. direction, between the rivers Alagon and Tietar: from the eastern part of the central range a branch proceeds in a N.W. direction to the Tagus. The climate in summer is hot, but not unwholesome, except in some swampy places along the Guadiana. There is then but little rain; dew, however, is abundant and sufficient to moisten the ground; and the nights are cool. Although the high mountains are covered with snow in the end of November, the winters are not severe. The soil is very fertile, and might be rendered highly productive by a proper use of the waters of the many rivers by which it is intersected. Agriculture, however, is wholly neglected, and the noble plains that might yield abundance of all sorts of products are devoted only to pasturage. Vast numbers of Merino sheep come annually from other parts to winter in these plains. Immense herds of swine are reared in this province and constitute a great source of support to the inhabitants, not only supplying them with food, but also forming a great article of export to other provinces,—the pork, bacon, and hams of these being in high esteem. The extensive forests of oak, beech, and chestnuts afford an abundance of food for hogs. Olive, fruit, and cork trees are numerous. Game is abundant, and fish swarm in the rivers and streams. Estremadura has mines of lead, copper, silver, and iron, but these are almost totally neglected; and the manufactures are few. The chief products are corn, wine, oil, hemp, and flax.

Estremadura, a province of Portugal, bounded on the N. and N.E. by Beira, S. and S.E. by Alemtejo, and W. by the Atlantic Ocean. It lies between 38. 6. and 40. 15. N. Lat., and between 7. 43. and 9. 32. W. Long., being about 140 miles in length from N. to S., by about 80 miles in breadth. The river Tagus divides it into two nearly equal parts, the northern being the more mountainous, but at the same time the more fertile of the two. A chain of mountains extending from Beira traverses the northern portion from N.N.E. to S.S.W., and terminates on the coast between the estuary of the Tagus and the sea. This range sends off spurs in various directions. Between Torres Vedras and Lisbon is an extensive chain of points, some formed by nature and others by art, and stretching in a general direction from E. to W. Along these Lord Wellington constructed a series of defensive works called the "Lines of Torres Vedras," by means of which he was able successfully to resist the advance of the French invaders. This mountain chain attains a height of 2300 feet, and separates the streams which fall into the Tagus from those that flow directly into the sea. The part lying N.W. and between it and the sea is mostly flat and sandy towards the coast, and either barren or covered with forests of pines. For about 50 miles N. of the mouth of the Tagus, however, or as far as Peniche, the coast consists of rocky cliffs, some of which attain a great elevation. S.E. of the ridge, and sloping towards the Tagus, the country is finer and better cultivated. The plains about Tomar and Santarem are very fertile, and abound with olive and other fruit trees. But the finest part of the province is that which lies S. of the lines of Torres Vedras towards Lisbon. Here the valleys are covered with villages, country seats, gardens, orchards, and vineyards. S. of the Tagus the country is mostly low and flat, and in several places unhealthy. The land rises towards Alemtejo, and several ranges of hills proceeding from that province enter Estremadura. The principal river is the Tagus, which falls into the sea below Lisbon. The Zezere is a large and rapid stream which rises in Beira, and flowing southward falls into the Tagus below Punhete. The Zatas and Almansor both rise in Alemtejo and flow at a short distance from each other into the eastern of the two branches into which the Tagus is divided above Lisbon. The principal of the rivers flowing directly to the sea are in the northern portion, the Lis, Alcoa, Arnoya, and Zizambre; and in the southern the Maroteca and the Sado, the last being the largest. Estremadura is divided into three districts as follows:

Districts.	Area in Square Miles.	Pop. in 1851.
Leiria	1310	140,114
Santarem	2310	161,342
Lisbon	3604	423,705
Total	7224	725,161

ESTREMOZ, a strongly fortified town of Portugal, province of Alemtejo, 24 miles N.E. of Evora. It is the seat of the provincial authorities, and has several churches and convents, an hospital, arsenal, cavalry barracks, and manufactures of earthen and hard wares. The castle stands on a commanding eminence. Pop. about 6000.

ESTRICH, in *Commerce*, the fine soft down which lies

immediately below the feathers of the ostrich. It is used as a substitute for beaver in hat-making, and the coarser kind is employed in the fabrication of a stuff resembling woollen cloth. It is sometimes written *estridge*.

ESTUARY. See ÆSTUARY.

ETAMPES (formerly ESTAMPES), a town of France, capital of a cognominal arrondissement in the department of Seine-et-Oise, on the Paris and Orleans railway, 30 miles S. by W. of Paris. It is situated in a fertile valley on the banks of two small streams which fall into the Juine immediately below the town. Etampes is tolerably well built, and is the seat of a tribunal of primary instance, a communal college, and an agricultural society. The church of Notre-Dame is a Gothic building of the thirteenth century, having a lofty tower and spire. The church of St Martin is a very fine edifice. The tower called *Guinette* is all that now remains of the ancient royal castle, built in the eleventh century by King Robert. Etampes has manufactures of soap, leather, and woollen goods, and a large trade in corn. In the town and vicinity are numerous flour-mills for the supply of Paris. Pop. (1851) 8083.

ETAWEH, a town and fortress of Hindustan, and the principal place of the British district of the same name. It is situated on the eastern bank of the Jumna, many parts of which, during the dry season, are 60 feet in height. The town is built on the heights, and, as it approaches the river, is divided into separate hills by deep ravines. In a commercial point of view the town enjoys great advantages, being situated at the junction of the road from Calpee to Agra with that from Cawnpore to the same place. A mile N.W. of the town is the European cantonment. Exclusive of the military, the population of Etaweh, by the census taken on January 1, 1853, is returned at 23,000 persons. Distant N.W. from Calcutta 710 miles. The district of which this town is the capital was divided from that of Cawnpore in 1840, and formed into a separate jurisdiction. It is almost wholly situate in the Doab between the Ganges and the Jumna, a small strip only being separated from the remainder by the latter river, and lying along its right or south-western bank. The population in 1853 was ascertained by official return to amount to 610,965. Of this number 401,367 are stated to be Hindus engaged in agriculture, 176,791 Hindus engaged in other pursuits, 9327 Mohammedans and others not Hindus, agricultural, and 23,480 of those classes non-agricultural. Hence it is seen that the Hindus constitute an overwhelming majority of the population. The right of the British government to this tract dates from 1801, when it was ceded by the Vizier of Oude, forming a portion of the possessions alienated by that prince in commutation of subsidy. The town of Etaweh is in Lat. 26. 46., Long. 79. 4. (E. T.)

ETCHING, a method of engraving on copper, in which the lines or strokes, instead of being cut with a tool or graver, are eaten in with aquafortis. See ENGRAVING.

ETELENT, a town of the Arabian Irak, on the river Tigris, 66 miles N.N.W. of Bassora.

ETEOCLES, a son of Œdipus and Jocasta. After his father's death he agreed to share the royalty alternately with his brother Polynices, but at the expiry of the first year he refused to surrender the throne. Polynices, summoning Adrastus, king of Argos, to his aid, headed the famous expedition of the Seven against Thebes. After a series of unavailing skirmishes, it was at last agreed between the two brothers that the war should be decided by single combat. An encounter ensued, and both combatants fell; and so fierce was their resentment, that according to tradition their ashes refused to mingle on the funeral pile.

ETERNITY, duration without beginning or end; duration without end. Among the Romans, *Æternitas* was used as one of the titles of the emperor, like *divinitas*, *majestas*, &c.; and, in the same spirit, Rome itself was designated the *Eternal City*. Æternitas was regarded as a divinity, without temples or altars; and was represented as a woman holding the sun in one hand, and the moon in the other. Her symbols were a phœnix, a globe, and an elephant.

ETESIAN WINDS (*Etesiæ*, from ἔτος, *year*) are such as blow at stated times of the year. Such are the monsoons and trade-winds, which in some parts of the world continue to blow in the same direction during stated seasons of the year. The term was applied by the ancient Greek and Roman writers to the periodical winds in the Mediterranean, from whatever quarter they blew.

ETHER, an element more pure and subtile than air; the matter of the highest region above. This fluid has been considered by the ancient, and many modern philosophers, to be diffused throughout the universe. With reference to the motions of the celestial bodies, it has been termed the *ethereal medium*. Newton believed in the existence of such a fluid.

ETHER, in *Chemistry*, an extremely volatile and inflammable fluid, produced by the distillation of alcohol with an acid. According to the acid employed in its preparation, it receives the names of nitric ether, sulphuric ether, &c.; but when perfectly rectified, the ether is the same whatever acid has been used. See CHEMISTRY.

ETHERIDGE, or ETHEREGE, SIR GEORGE, a wit and comic writer in the reigns of Charles II. and James II., was descended from an ancient family in Oxfordshire, and born in 1636. His youth was spent in travelling, and also partly in the study of the law. His first dramatic performance, entitled *Comical Revenge, or Love in a Tub*, appeared in 1664, and introduced him to the leading wits of the time. In 1668 he produced a comedy called *She Would if She Could;* and in 1676 he published another, entitled *The Man of Mode, or Sir Fopling Flutter*. This latter piece he dedicated to the Duchess of York, who, on the accession of James II., procured his appointment as ambassador, first to Hamburg and afterwards to Ratisbon. His knighthood was purchased to gratify the ambition of a rich widow, to whom he paid his addresses for the sake of recruiting his fortune. The precise date of his death is unknown, but it is generally agreed that he did not long survive the Revolution. The works of Etheridge are characterized by considerable vivacity and wit; qualities, however, which only render their licentiousness more dangerous. From the simplicity and pliancy of his disposition, he became known under the familiar appellations of Gentle George, and Easy Etheridge.

ETHICS (ἦθος, *custom, moral character*), the science that treats of the nature and value of moral distinctions; commonly called moral philosophy. See MORAL PHILOSOPHY.

ETHIOPIA. This term was used by the ancients in two senses. In its widest acceptation Ethiopia comprised the vast and unexplored country lying between the Red Sea and the Atlantic, and along the line of the equator northwards to the inhabited countries bordering on the Mediterranean. In a more restricted sense it was applied to the kingdom of Meroë, which, in contradistinction to the other, was called the civilized Ethiopia. An account of this country, as far as it has been explored, will be found under the heads AFRICA, ABYSSINIA, MEROE, &c.

ETHIOPS, a name given by the alchemists to several metallic preparations of a black colour. Thus the black oxide of iron was called *ethiops martial;* the black sulphuret of mercury, *ethiops mineral;* and the black oxide of mercury, *ethiops per se*.

ETHNARCHA (ἔθνος, *nation*, ἀρχή, *command*), in *Antiquity*, a governor or ruler of a country. The title of ethnarch, like those of tetrarch and phylarch, appears to have been used by the Romans to designate such tributary princes as were not of sufficient importance to be styled kings. See TETRARCH.

ETHNOLOGY.

ETHNOLOGY is a word of Greek derivation, belonging to the same class, and formed on the same principles, as *Geology*, *Astrology*, *Biology*, *Physiology*, &c. The initial element, *Ethno-*, means, in its primary sense, *nation;* in its secondary, the *Varieties of the Human Species.* These are the true objects of ethnological study. Ethnology has been defined to be the *Science of Races*, but to this definition there is an objection. What is a *race*, if it be neither a *species* nor a *permanent variety?* Then, if it be neither of these, nor yet anything different from them, what is the use of the term? The answer to this has been suggested by Dr Prichard. Suppose an inquirer into the natural history of mankind to be doubtful whether a certain division constitute a *species* or only a *variety*, his argument may take such a form as to preclude him from the use of either term. His judgment is in suspense, and, as a consequence thereof, his phraseology is undefined. In such a case *race* is a useful word, being one which can be used when there are doubts as to whether we are dealing with a separate species or a variety of some species already recognised. Hence the term is *subjective*, *i.e.*, it applies to the opinion of the investigator rather than to the object of his investigation; its power being that of the symbol of an unknown quantity in algebra. Useful, however, as it is, it is more so in the investigation of a doubtful problem than in the exposition of a known series of facts.

Another synonym to the word *Ethnology* is *The Natural History of Man. The Physical History of Man* is another. Both these convey the idea of ethnology, and something more, *i.e.*, of the closely allied science of *anthropology.* Between these the *Natural History of Man* is divided; *anthropology* determining the relations of man to the other members of the animal kingdom, *ethnology* the relations of the different divisions of mankind to each other. There existed the materials for anthropology when the first pair of human beings stood alone on the face of the earth, and there would exist the same materials for anthropology if the world were reduced to its last human family, if it had no inhabitants but Englishmen, or none but Chinese; none but red men of America, or none but blacks of Africa. Were the uniformity of feature, the identity of colour, the equality of stature, the rivalry of mental capacity, ever so great, there would still be an anthropology. This is because anthropology deals with *man as compared with the lower animals.* As anthropologists we consider the structure of the human extremities, and enlarge upon the flatness of the foot and the flexibility of the hand. The one is subservient to the erect posture, the other to the innumerable manipulations which human industry demands. We compare them with the fins of fishes, or the wings of birds; in doing which we take the most extreme contrasts we can find. But we may also take nearer approximations, *e.g.*, the hands of the higher apes. Here we find likeness as well as difference; difference as well as likeness. We investigate both, and record the result either in detail or by some general expression. Perhaps we pronounce that the one side gives the conditions of an arboreal life, the other those of a social state; the ape being the denizen of the woods, the man of towns and cities; the one a climber, the other a walker. Or we compare the skull of the man and the chimpanzee; noticing that the ridges and prominences of the external surface, which in the former are merely rudimentary, become strongly marked crests in the latter. We then remember that the one is the framework for the muscles of the face, the other the case for the brain. All this is anthropology as opposed to ethnology, the latter being a study which has no existence where there is no variety. The more manifold this variety the greater the scope of the ethnologist, and the wider his field. No matter how we classify our varieties. Whether the individuals and groups of individuals which exhibit them form different species of a genus, different genera of an order, or merely different varieties of a species, is indifferent.

The word, like the department of knowledge that it expresses, is new; so new that it may almost be said to be unfixed both in power and in form. Instead of *ethnology* many writers say *ethnography.* Some use the two words indifferently. Others use both, but distinguish between them; the latter meaning the *descriptive*, the former the *speculative*, portion of the subject.

No science has its relations to the other branches of study more accurately defined than ethnology. It is connected with zoology proper through anthropology, anthropology differing from zoology in its greater simplicity in one respect, and its greater complexity in another. So far as it deals with a single order, genus, or species, anthropology is simpler than zoology. So far as the characteristics of this order, genus, or species are peculiar, zoology is simpler than anthropology. The chief criteria of the animals below man are physical rather than moral: of man they are moral rather than physical. Anthropology gives us the *naturalist* view of our species.

Ethnology, on the other hand, gives us the *historic* view of it. Yet ethnology is different from ordinary history. In ordinary history we trace the effects of human actions upon humanity, the influences being moral. In ethnology we investigate the influences of soil, climate, nutrition, and similar agencies, for the most part physical. There is a difference between the two studies in all this. There are further points of difference. The facts with which history proper (civil history) deals are of later date than those of the ethnologist, the arena of the ethnologist being in the earlier period of the world's history, a period for the most part anterior to the existence of written records and the other forms of historic testimony. In this way ethnology is the general archæology of man, to which the special branches of that subject are, more or less, subordinate. The methods of the ethnologist and the civil historian are not less different than the fields in which they work. History collects its facts from testimony; ethnology infers them by means of its own proper induction, arguing backwards, from the known to the unknown, from the effect to the cause. It was not until the publication of one of his latest works that Dr Prichard recognised the inductive character of ethnological research, and the extent to which his science was thereby separated from that of the civil historian. However, in his anniversary address to the Ethnological Society in 1847, he distinctly recognised it. "Geology, as every one knows, is not an account of what nature produces in the present day, but of what it has long ago produced. It is an investigation of the changes which the surface of our planet has undergone in ages long since past. The facts on which the inferences of geology are founded are collected from various parts of natural history. The student of geology inquires into the processes of nature which are at present going on, but this is for the purpose of applying the knowledge so acquired to an investigation of what happened in past times, and of tracing, in the different layers of the earth's crust, displaying, as they do, relics of various forms of organic life—the series of the repeated creations which have taken place. This investigation evidently belongs to history or archæology, rather than to what is termed natural history. By a learned writer, whose name will ever be connected with the annals of the British Association, the term palæontology has been aptly applied to sciences of this department, for which physical archæology may be used as a synonym. Palæontology includes both geology and ethnology; geo-

logy is the archæology of the globe; ethnology that of its human inhabitants." For the important term Palæontology we are indebted to Dr Whewell; for the best illustrations of the palæontological method, to Sir C. Lyell. Each of these writers, though specially engaged upon other subjects, has largely contributed to impress upon English ethnology, at least, a scientific character—having done more than any proper ethnologist towards defining the *method* of ethnological investigations.

A great portion of the subject-matter to which this method applies has already been suggested by the relations of ethnology to anthropology on the one hand, and to civil history on the other. In the former, we give prominence to the phenomena of physical conformation—bodily and mental structure. In the latter, we investigate the phenomena and development of the social state. Subordinate to these studies are the ordinary preliminaries to a naturalist's and to a historian's education. To these, however, ethnology superadds much that is peculiar and proper to itself—just as the study of the varieties of such species as the horse, the domestic fowl, the sheep, or the dog, introduces a multitude of questions that the study of simpler and less varied species dispenses with. Let a naturalist employ himself on say the dog. He will assuredly find that the study of the *variety* far surpasses in complexity that of the species. But what if the dog-tribe had the use of language? What if the language differed with each variety? In such a case the study of canine ethnology would be doubly and trebly complex, though at the same time the data for conducting it would be both increased and improved. A distant, a very distant, approach to this exists. The wild dog howls; the companion of man alone barks. This is a difference of language as far as it goes, which is far enough to foreshadow the importance of the study of language as an instrument of ethnological investigation. Again, what if the dog tribe were possessed of the practice of certain human arts, and if these varied with the variety? What if they buried their dead, and their tombs varied with the variety? if those of one generation lasted for years, decenniums, or centuries? The ethnology would again increase in complexity, and the data would again be increased. The graves of an earlier generation would serve as unwritten records of their habits of sepulture, and these differences in the mode of sepulture would be measures of some difference in the way of ethnology—indicative, perhaps, of some moral peculiarity; or, perhaps, indicative only of certain physical conditions of soil, climate, animal or vegetable products. The nidification of birds is a real example of this kind.

Hence the domain of the ethnologist touches those of the archæologist and the philologue. But by far the most important of the accessories to ethnology is physical geography, studied with a special view to the relations between the bodily conformation of the occupants of a given area, and its climatological and other conditions. That any amount of intertropical influences can convert a white man into a negro is what many deny, and that on reasonable grounds. That any degree of arctic cold can convert a negro into an Eskimo is in like manner doubted. Neither is the possibility of two such extreme forms being developed out of some intermediate one at all freely admitted. In other words, the effects of climate, &c., upon the human frame are by no means held to be indefinite. That climate, &c., however, have *some* influence no one denies, though many limit it to a *minimum*.

So much for the *method*. As to the *results* of ethnological investigation, they are either so many points of classification, or so many points of history. They are so many points of classification, if we suppose that the differences between the different divisions of one kind have always been what they are at present; and they are so many points of history (*physical* history), if, supposing the whole species to have once been the same throughout, we deduce the present distinctions from the influences of climate and other causes acting during a long or short space of time.

It has been stated that the science is a new one; so new as for its method to have been but recently explained, and so new as for its nomenclature to be, even at the present moment, more or less unfixed. The materials, however, for a science are always older than the science itself. Hence, we find in more writers than one (some of considerable antiquity), ethnological notices, and even ethnological trains of reasoning, though no system of ethnology. In *Greek* literature not a little of this sort of information is found in Herodotus, an unconscious and instinctive ethnologist. He has described manners, and he has given glosses from several barbarous forms of speech. In Hippocrates we find an approach to a theory as to the effect of the external physical conditions of climate and the like on the human frame. Something, too, we find in Aristotle, and something in Plato; nothing, however, by which the study of man as an animal is recognised as a separate substantive branch of science. More than this, in works where the description of new populations was especially called for, and where the evidence of the writer would have been of the most unexceptionable kind, we find infinitely less than there ought to be. How little we learn of Persia from the *Cyropædia*, or of Armenia from the *Anabasis;* yet how easily might Xenophon have told us much!

The opportunities of the *Romans* were greater than those of the Greeks, and they were better used. This we see in Sallust's sketch of Northern Africa, and in Cæsar's of Gaul. The nearest approach, however, to a proper ethnological monograph is the *Germania* of Tacitus. It is far, however, from either giving us the facts which are of the most importance, or exhibiting the method of investigation by which ethnology is most especially contrasted with history. But the true measure of the carelessness of the Romans upon these points is to be taken by the same rule which applied to that of the Greeks, *i. e.*, the contrast between their opportunities and their inquiry. How much they might have told us of such vast areas as Asia Minor and Persia—as the Danubian Principalities (Dacia), as Pannonia, Dalmatia, and Rhætia. We *now* ask, with interest and uncertainty, such questions as who were the Getæ? who the Thracians, &c? Some answer *Germans*, some *Slavonians*, some *an extinct division of our species.* The commonest slave-dealer of Byzantium or Olbiopolis could have told us more than all the learned men since employed on such subjects.

We approach our own times, and the field of observation enlarges. Africa is circumnavigated, the parts beyond India visited, America discovered. The world becomes known in its extremities as well as in its centre. Nevertheless, the human naturalists anterior to Buffon and Linnæus, are like the great men who lived before Agamemnon.

Buffon made a general history of man, as well as a theory of the earth, important portions of his great work, prominent and full. Buffon gives us description rather than classification; Linnæus classification rather than description. How thoroughly zoological is the following table from the first edition of the *Systema Naturæ.*

QUADRUPEDALIA.

Corpus hirsutum, pedes quatuor, feminæ viviparæ, lactiferæ.

ANTHROPOMORPHA.

Dentes primores iv utrinque vel nulli.

HOMO	............Nosce teipsum.......H.	Europæus albescens. Americanus rubescens. Asiaticus fuscus. Africanus niger.
SIMIA	Anteriores, Posteriores, ...Digiti 5. Digiti 5....	Simia cauda carens. Papio satyrus.
	Posteriores anterioribus similes...	Cercopithecus. Cynocephalus.
BRADYPUS	...Digiti 3, vel. 2. Digiti 3.	Ai ignavus. [1]Tardigradus,

In 1790, the first decad of the anatomical descriptions of Blumenbach was published, the special part investigated being the cranium; and that with a view to ethnology rather than to anthropology.

Little was said about the *differentiæ* between the human skull and the skull of the higher apes; much about the distinctions between crania from America, crania from Asia, and crania from Africa. The last pentad of these researches was published in 1820. It is Blumenbach to whom we owe the division of mankind into the following five classes; (1.) the Caucasian; (2.) the Mongolian; (3.) the Æthiopic; (4.) the American; and (5.) the Malay; the nomenclature also being Blumenbach's. Of the five terms before us, the second, the fourth, and the fifth are current without being inconvenient. The third (Æthiopic) is rarely used. The first (Caucasian) is unfortunately as current as it is both incorrect and inconvenient.

The *Règne Animal* gives the anthropological characters of man fully, placing him as the only species of the genus *Homo*, the only genus of the order *Bimana*. The ethnology is that of Blumenbach modified, the Malay and American divisions being subordinated to the Mongolian. Meanwhile, our improved knowledge of New Holland and New Guinea had given prominence to the Australian and Papuan varieties—varieties which somewhat complicated the previous classifications, but which were too slightly investigated to create an entire revision of it.

It was the anatomists and zoologists that gave to ethnology its naturalist aspect. The philologues, on the other hand, viewed it as historians.

Philological ethnology has advanced, at least, as rapidly as physiological. We may also add that it began earlier. As early as the voyage of Magalhaens, vocabularies of languages, which could only be valuable as ethnological materials, were collected—Pigafetta being the collector. Reland knew of the existence of Malay words in the Island of Madagascar. Leibnitz had speculated on the Bask language. The Abbé Hervas established a voluminous correspondence with the missionaries of the *Propaganda* wherever they were found, and his *Saggio del Universo* gives us the results. In 1801, the *Mithridates* of Adelung appeared, giving specimens, more or less imperfectly classified and analyzed, of all the known languages of the world. Notwithstanding all this the world had yet to see a special and proper ethnologist. No philologue had known much of either anatomy or zoology; no anatomist or zoologist of philology. Nor yet had any one seen the subject in its full dimensions, or treated it otherwise than as an accessory to some other department of knowledge. With the naturalist it was an adjunct to zoology, with the scholar to comparative philology. The first who combined the two methods of investigation with a full perception of the magnitude of the subject was Dr Prichard—no special naturalist, no special anatomist, no special philologue, but enough of all to make him the first and last of ethnologists. Such is his position, and in it we get a measure of the extent to which his subject is a new one.

The present author will now lay before his readers an exposition of the primary divisions and main sub-divisions of Mankind, reserving his criticism until the classification has been completed, premising that it is only where it differs from that of Dr Prichard that he feels that any real opposition of doctrine is encountered. The groups of all other writers must be looked upon as groups founded upon partial and incomplete examinations, groups formed (so to say) under no *ethnological responsibility*, but merely as extraneous speculations—so much zoology, so much anatomy, so much history, or so much philology having been diverted into a new and near channel.

This is only, however, to the writers who have delivered opinions upon *general* and *systematic* ethnology that this applies. The authorities that, upon any special division of the subject, demand respect and attention are numerous. To go no further than the limits of the English language, we have for American ethnology the names of Morton, Gallatin, Hale, Schoolcraft, and others—for Malay and Indo-Chinese, Leyden, Crawfurd, Logan, Earle, &c.—for Indian and Himalayan, Hodgson, and many others besides.

What portion of the earth's surface is it best to start with? It is as certain that this is an inquiry of considerable practical importance as that it is one to which a variety of answers may be given. It is important, because the question as to the dispersion of mankind over the earth implies the existence of some special locality as a starting-point; and the starting-point being given, a tendency arises to attach to it what we have called the *typical standard* or *average* sample of our species. However much we may guard against these views, they continually obtrude themselves on our attention. On the other hand, the answers concerning the point of the earth's surface, and the division of the earth's inhabitants, with which it is most convenient to begin, are numerous. They differ with the point of view favoured by the inquirer. The zoologist, the philologist, answer differently. The starting-point that purely zoological considerations more especially suggest are the countries of the anthropoeid (or anthropomorphic) apes, countries which agree with each other in being intertropical (indeed equatorial), but which lie in distant meridians—Western Africa and the southern extremity of Asia—the banks of the Gaboon and Borneo. Purely naturalist in our view, we may argue not only from the general phenomena of the geographical distribution of animals, but also from the natural conditions of human life as compared with the artificial. In the protoplasts of his species the zoologist sees but so many naked bipeds, with the capabilities, indeed, of working out for their future behoof the essentials of clothing, the use of fire, and the like, but, *in the first instance*, intolerant of any climate but the mildest, and incapable of sustenance on any soil but the most luxuriant. Hence, from the purely zoological point of view, the tropics are the cradle of our kind; and of the intertropical points, the habitats, or the parts about them, of the anthropoeid apes. The philologist, on the other hand, looks towards China, Tibet, and the Trans-Gangetic Peninsula; inasmuch as the peculiar character of the languages of these parts arrests his attention. They are monosyllabic, and destitute of inflexions. Such being their character, they are reasonably supposed to give us the simplest existing forms of human speech. Whether this view be right or wrong, it evidently favours the area of the so-called monosyllabic tongues being taken at the beginning of any ethnological exposition.

Another centre is what we call the logical one—logical because it is formed upon general rather than special grounds, and because it is based upon the principle that *forces must not be multiplied unnecessarily*. If the earth were one large circular island; if its populations were admitted to have been diffused over its surface from some single point, and if that single point were at one and the same time unascertained and requiring investigation, what would be the method of our inquiries? I suppose that both history and tradition are silent, and that the absence of other *data* of the same kind force us upon the general probabilities of the case, and a large amount of *à priori* argument. We should ask what point would give us the existing phenomena with the least amount of migration, and we should ask this upon the simple principle of not multiplying causes unnecessarily. The answer would be—the *centre*. From the centre we can people the parts about the circumference without making any line of migration longer than half a diameter, and without supposing any one out of such numerous lines to be longer than the other. This last is the chief point, the point which more especially

fixes us to the centre as a hypothetical birth-place, since the moment we say that any part of the circumference was reached by a shorter or longer line than any other, we make a specific assertion requiring specific arguments to support it. These may or may not exist. Until, however, they have been brought forward, we apply the rule *de non apparentibus*, &c., and keep to our conventional and provisional point in the centre—remembering, of course, its provisional and conventional character, and recognising its existence only so long as the search for something more real and definite continues.

Under any or all of these principles some portion of Southern Asia becomes our starting-point. Let the particular area be the Trans-Gangetic or Indo-Chinese peninsula, an area which coincides with none of our views exactly, but approximates them all. Of course it is, more or less, conventional, hypothetical, and provisional. It is by no means said to give us the cradle of our species. It is only said to be a convenient centre from which we may follow out so many lines of migration in so many different directions.

A.

ASIATICS AND NORTHERN EUROPEANS—POLYNESIANS, AMERICANS.

CLASS I.

Contains those populations whose physical conformation is, either typically or sub-typically, MONGOL, having been generally recognised as such.

Area.—Northern, Central, and South-Eastern Asia; Northern Europe.

DIVISION I.—*Languages monosyllabic.*

Populations.—The Burmese, Siamese, Tibetans, Peguans, Kambogians, Cochin-Chinese, Chinese, various mountain tribes, Nepalese, Lepchas, Limbus, Chepang, Kocch, Bodo, Dhimal, Assam hill tribes, Islanders of the Indian Archipelago, the Nicobar and Carnicobar Isles, the Andamans.

The language of all the members of this group is not only monosyllabic, but destitute (or nearly destitute) of inflections. We may add, that the absence of inflections arises from the fact of their non-development—not from development followed by subsequent loss. The colour of the skin varies from a light yellow to almost black, the colour of the hair being more uniform, as also its texture. So is the stature—most of the populations under notice being undersized rather than over-sized. The civilizational forms are extreme, *i. e.* there is the proverbial industry of the Chinese at one end of the chain, at the other the barbarism of the Andaman Islanders. The Chinese section of this group is far greater than all the others put together, hence (if we look only to the number of individuals) the religion of Fo is the dominant creed. The smaller and obscurer tribes of the mountain ranges between Cochin-China and Cambogia, Cambogia and Siam, Siam and the Burmese Empire, China and Assam, the Burmese Empire and Arakhan, claim, on the part of the ethnologist, an amount of attention that the civil historian has never yet given them. The Andaman Islanders are placed in this group on the strength of the language. Their colour is against their belonging to it.

DIVISION II.—*Turanians—Languages other than monosyllabic.*

Turanian area (either now or originally).—Mongolia, Mantshuria, Siberia, Tartary (Independent and Chinese), Turkestan, Anatolia, Rumelia, parts of Persia, Armenia, Syria, the Crimea, Lapland, Finland, Esthonia, Livonia, Courland, governments of Archangel, Olonetz, Novogorod, Twer, St Petersburg, Yaroslav, Vologda, Permia, Viatka, Kazan, Astrakhan, Simbirsk, Saratov, Nizhgorod, Penza, Tambov—Hungary—the Kurile Isles, Kamskâtka, Japan.

Groups.—1. The Mongolian; 2. the Turk; 3. the Ugrian; 4. the Tungûs; 5. the Peninsular.

1. *The Mongolians.*—Mongolia is part of the largest steppe in the world, extreme in climate, and poor in soil, and the Mongolians are the most nomade of populations, their physiognomy and habits being uniform over a vast extent of country. The skull is broad, the face flat, the eyes oblique, a crescentic fold at the inner angle separating them in appearance more than they are in nature. The extent to which the Mongolian physiognomy has been considered typical has already been noticed. That the calves of the legs are undeveloped is no more than the natural effect of their equestrian habits. A tent is the house, milk and flesh the food of the Mongolian. Of the milk, when fermented, he makes his intoxicating drink, *kumiss*.

Temudzhin (Jenjiz-khan) is the hero and conqueror who has given the Mongolians their chief historical importance, China being the point towards which the edge of the Mongol sword has most turned. But the spirit of conquest has long been dead. The Mongolians under China are peaceable Buddhists, eminent for their amenability to priestly influence. Some few of them are independent, others subjects to Russia, where they are known as Kalmuks. Of these some have been imperfectly Christianized. The Kalmuks of the governments of Caucasus and Astrakhan are a colony. So are some small Mongol settlements in Cabul.

2. *The Turks.*—*Turk*, in ethnology, is a word of a very wide import. It denotes all the populations whose language is allied to that of the Turks of the Ottoman Empire. These, indeed, are best called *Osmanli*, while *Turk* means the Turcomans, both of Asia Minor and the Persian frontier, and a vast number of important tribes besides. No division of our species surpasses this in interest and importance. The original Turk area is of the largest. Conquest and encroachment have made it larger still—conquest and encroachment in every direction. How far this has moved westward we know, for we know that the Osmanli Turks of Turkey are the latest invaders of Europe. In Asia Minor they are older occupants, but even there they were originally invaders. They are to be found, mixed with Arabs, in Syria and Palestine, even to the frontier of Arabia. Their great centre, however, is Independent Tartary. From this they have spread as far east as Chinese Tartary; for, not only are the Uzbeks of Bokhara Turks, but the tribes of Khoten and Yarkend are Turks also. Bounded on the east by the Mongols, the Turk area prolongs itself northwards; and that to the very verge of the Arctic Sea. The Lena is a Turk river, and the Yakut Pagans who occupy it speak a language closely akin to the Osmanli of Constantinople. Add to this that all the *Tartars* (so-called) of the Russian Empire belong to the same stock. In Kazan, Astrakhan, and the Crimea, they have founded empires, and attained a civilization like that of the Ottomans. In Orenburg they are, perhaps, as much Ugrian as Turk—this being the view taken of the Bashkirs, whose language, however, is undoubtedly Turk. The Barabinski steppe is Turk. Nogays (wherever found) are Turk. The numerous tribes, more or less isolated, on the Upper Obi, and Yenesey, are Turk. So are some as far eastwards as the Lake Baikal. In Caucasus the Karatshai and Basiani are Turks. With an area so large, the Turk family is subjected to almost every physical influence. Again, it occupies some of the highest inhabited levels, *e. g.* the table-land of Pamer, at the head of the Oxus. As far as any general statement can be made in respect to its distribution, it may be said that it is an *overland* one. Few Turks are in any of the maritime localities, or on any of the deeply indented sea-boards. Again, the Turk area is fitted for a pastoral, rather than an agricultural life. Still, there are excep-

tions. Along the Jurgan and Lower Oxus, the Turcomans, who are elsewhere so pastoral, are industrial tillers of the soil. What applies to the Turk habits applies also to the Turk creed. As a general rule they are Mohammedans, just as (as a general rule) they are pastoral. Yet many of the Turks under Russia are Christians, whilst the Yakut are Pagans. A few perhaps, on the Mongol frontier are Buddhists. Part of the Turk area is covered with archæological remains,—which yet remain to be accurately investigated, *e. g.* the Russian governments of Kazan, Astrakhan, Saratov, as well as Independent Tartary. So is the Crimea. Neither the Turks nor the Mongols have been eminent as builders of cities. Mohammedan as is the Turk religion in general, it was, nevertheless, preceded, in some parts at least, by Christianity. Hence, the earliest Turk alphabet—which was of Syrian origin, introduced by the Nestorian missionaries, the Uighur form of speech being the one to which it was applied. From the Turks the Mongols took it, from the Mongols the Mantshu. In physiognomy the Turk is Mongolian; the Osmanli of Europe and, in a less degree, the Turkoman of Asia Minor, being exceptional sections modified by intermixture. The family is pre-eminently a family of conquerors. Tamerlane, the Seljukians, and the Osmanli, were Turk. The obscure conquest of the valley of the Lena by the ancestors of the present Yakuts was Turk. There is evidence—whether good or bad is doubtful—that one of the early conquest of China was Turk. A case may be made in favour of Asia Minor and Syria having been overrun by Turks long before the Seljukian period, and, indeed, the very dawn of history. A case can be made out for the Parthians (and possibly the Persians) having been Turk. That the Comanians, Uzes, Petshinegs, and Avars, were Turk, is certain. It is almost certain that the Huns of Attila were the same—probably the Bulgarians also (though now Slavonized). Lastly, the Scythians of Europe were Turk, rather than ought else.

The chief divisions are—the Kirghiz and less important tribes in Independent Tartary, the Uzbeks of Bokhara, the Turks of Chinese Tartary (of Uighur origin), the Turcomans, the Basiani and Karatshai of Caucasus, the Osmanli, the Crim Tartars, the Nogays, the Bashkirs (of mixed blood), the Barabinski, &c., of Siberia.

3. *The Ugrians.*—The Ugrian family is common to both Asia and Europe, being the most western member of the former, the most eastern (north-eastern) of the latter, continent. The Uralian range lies well-nigh in the centre of its area. As compared with a Mongolian, a Ugrian has a European—as compared with a German, a Mongol, physiognomy. The hair is often red; indeed, the Ugrian is the first great section of our species where a light complexion becomes anything like general. Placed between two great powers—the Turk and the Russian—the Ugrian family has been greatly encroached upon, greatly broken up; so that at present it presents but fragments of its former greatness. Originally, I think it extended from Caucasus to the Icy Sea, from the Dnieper to Behring's Straits—an area not less, but rather greater, than that of the Turk, Nine-tenths of what is now Russian was once Ugrian.

The primary divisions into which this stock falls are—(1), the Eastern; (2), the Western, Ugrians.

1. The *Eastern* are the Samoyeds, the Yeniseians, and the Yukahiri, all populations of Asia, the Yukahiri being the most eastern. None of these are in contact with each other, inasmuch as northern offsets of the Tungûs and Turks separate them. They are all nomades—all in the *tundra* rather than in the forest.

2. The *Western* Ugrians consist of the Laplanders, the Finlanders, the Permians, Siranians, and Votiaks of the Russian governments of Perm, Vologda, and Viatka; the Tsheremiss, the Mordvins, the Tshuvash, on the middle Volga; the Voguls and Ostiaks on the ridge of the Ural mountains, and along the rivers Obi and Yenesey; and, finally, the Majiars of Hungary. Between the extreme types there are broad differences, *e.g.* between the Laps and Majiars. So there are in respect to their social and intellectual histories.

The two great representatives of Ugrian stock are, (1), the Finlanders of Finland, and (2), the Majiars of Hungary, the latter being recent conquerors and intruders, the date of their conquest and intrusion being the tenth century. That the difference between the Finlander and the Lap is so great as it is, must be accounted for by the displacement of transitional forms. All Norway and Sweden was once Lap. So was Courland, and, perhaps, certain districts still farther west. The Ugrian creeds are either Christian or pagan, there being little or no Mohammedanism, except, of course, where there has been Turk intermixture. At present the most southern Ugrians (laying the Majiars out of the account) are the Mordvins of the governments of Saratov and Astrakhan.

Few suggestions as to the early history of the more obscure nations are more important than that of Mr Norris respecting the third language of the Arrowheaded Inscriptions. It is to the effect that it was Ugrian. If so, the Ugrians from the southern part of the Uralian range may have overrun Persia several centuries B.C., just as certain Majiar Ugrians overran Hungary and Transylvania several centuries A.D.

The Samoyeds have been added to the Ugrian family by Castren, the Yeneseians and Yukahiri by the present writer. It is doubtful whether the group has yet attained its due dimensions. Possibly the Eskimo may have to be added to it, as well as some American tribes. Possibly, also, the Kamskadale and Koriaks; an addition affecting the value of the Peninsular group.

4. *The Tungûs.*—The Tungûs area lies to the north and east of the Mongol. On the drainage of the Amur the older geographical names are Tungûs, the newer Chinese. This shows that the latter nation is the encroaching one. On the other hand, it is Tungûs dynasty (the Mantshu) that is dominant in the Celestial Empire. Divided in their political relations between Russia and China, the Tungûs differ from each other in creed. In China they are Buddhist, in Russia imperfect Christians and pagans. The Mantshus have adopted the Mongol alphabet. Upon some of the tribes to the north of them the Tungûs have encroached and effected displacements, the probable direction having been from south, or south-east, to north. Their appearance in history is late, inasmuch as their area lay beyond the pale of Greek, Roman, and Arab intercourse. It is the Chinese who most mention them; a tribe called *Niuju* more especially. This term (Niuju), Daurian, Tshapodzhir, Mantshu, and Lamut, are the most currently known names of the Tungûs family. The Tshapodzhir tattoo their faces. The different zoological regions of the Tungûs area give us the divisions of the *Horse* Tungûs, the *Reindeer* Tungûs, and the *Dog* Tungûs. The Tungûs has encroached upon the Ugrian area, isolating certain members of it, *e.g.* the Yukahiri.

The word *Tungûs* = *donki* = *man*, a root that reappears in the Yeniseian, and more than one American language. *e.g.* the north-western dialects of the Athabaskan (*vid. infra*).

5. *The Coreans, Japanese, Kurile Islanders, Kamskadales, and Koriaks.*—I throw all these into a single class of value as yet undetermined. I suggest for it the name *Peninsular*, from the extent to which its area is affected by the neighbourhood of the sea. In the way of language, the affinities of these populations are Tungûs and Ugrian rather than monosyllabic, their physiognomy being unequivocally Mongolian. The civilization varies; the proximity of China having told favourably on Japan, less favourably on Corea, and little at all on the Kurile Islanders. Of the Kamska-

dale peninsula the aborigines are nearly extinct. Not so the Tshuktshi of the coast of the Arctic Ocean. *They* hold their own bravely; bold in temper, strong in body.

Ermann has remarked that the Kamskadale and Ostiak languages appear liker each other than either are to the intermediate tongues, *e. g.*, the Tungús and Mongol. If so, we see our way to the possibility of the Peninsular group (either wholly or in part) becoming subordinated to the Ugrian. Probably, too, the Kamskadales and Koriaks belong to one and the same division of this group. The Peninsular, Ugrian, and Tungús forms of speech are the most American of the Asiatic languages, the Tshukshi being also American in physiognomy.

CLASS II.—IRANIANS.

GROUPS.—1. The Persians; 2. the Paropamisans; 3. the Armenians; 4. the Dioscurians (*i. e.*, the Caucasians of Caucasus, or Caucasians in the limited, proper, and convenient sense of the term).

Physiognomy.—Caucasian (in the general, Blumenbachian, and inconvenient sense of the term) rather than Mongolian; in some cases Mongolian.

Languages.—Pauro-syllabic (*i. e.*, of so few syllables as to approach the monosyllabic character). Inflections few; probably, in all cases from non-development rather than loss; certainly so in the Dioscurian division.

Area.—Kurdistan, Persia, Afghanistan, the Kohistan of Cabul, Bokhara, Kafiristan, Armenia, Caucasus.

1. *Persians.*—Divided into Persians Proper, Kurds, Bilúch, Afghans. Shiite Mohammedans, and fire-worshippers in religion. Christianity rare.

The Persians of history must be looked upon as a mixed race, large infusions of Turanian blood having been introduced from the northern frontier. In the comparative compression of the cheek-bones, the oval outline of the face, and the prominence of the nasal bones, we find wide departures from the Mongol type. Aquiline noses first appear in this group, just as red hair first appeared with the Ugrians. The philology of Persia is closely connected with that of India.

2. *Paropamisans.*—Occupants of the ancient Paropamisus, *i. e.*, the Kohistan of Cabul.

The so-called Kafres of Kafiristan, to the north of Peshawer, give us the type of this division—which, perhaps, should be subordinated to the proper Persian. The Kafres still retain the paganism of the times anterior to Mohammedanism. Their country is inaccessible, so that they are amongst the obscurest tribes of Asia. Their physical appearance is fine. The Chitrali, Dardoh, probably the Cashmirians, along with certain fragmentary populations of Cabul, are Paropamisan.

3. *Armenians.*—The features more massive than those of the Persian; the creed Christian rather than Mohammedan; the language, as also the alphabet, peculiar; the civilization old. Like the Jews, the Armenians are scattered beyond the limits of their own area.

4. *Dioscurians.*—This is a term suggested by the author. It is taken from the town *Dioscurias*, wherein Pliny says that 130 interpreters were wanted; so numerous were the dialects of Caucasus. They are numerous now. Hence the suggestion of the word instead of the awkward term *Caucasian in the limited sense of the word*, a circumlocution otherwise necessary from the Blumenbachian use of the adjective in another sense.

In the western Caucasus the physiognomy is Persian rather than Mongolian; in the eastern it approaches the Mongolian. The language has its nearest affinities with the Tibetan and other monosyllabic tongues; a statement which, in the case of the *Irôn*, many philologues are indisposed to admit. The sections and chief subsections of the Dioscurians are as follows:—

1. *Circassians.*—Adighé, Abassians, Kabardinians, &c.
2. (*a*) *Tshetsh* or *Mizhdzhedzhi.*—Central and on the watershed between the Terek and Kuban rivers; probably to be subordinated to the—

(*b*) *Lesgians*, or Eastern Caucasians.—The Avars, the Anzukh, the Andi, &c.

3. *Irôn*, or *Osset.*—Central and on the watershed between the Kuban and the Kur.
4. *Georgians.*—Mingrelians, Imeretians, Suan, Lazians, and Kartulinians.

CLASS III.—INDIANS.

In India we have a physiognomy referable to two types, one Persian rather than Mongol, the other Mongoloeid. In each case the skin is dark, *i.e.*, brunette, or black. The chief creeds are Buddhist and Brahminic. The languages for the south are undoubtedly of Tamul origin. For the *north*, see LANGUAGE, *Notes.* Among many of the hill-tribes neither of the leading religions have yet struck root. Hence the original paganism of the peninsula still remains.

The minute ethnology of India is as interesting as it is complicated. It is the ethnology of a country of castes; of a teeming, ingenious, and industrious, but rarely independent population; of an ancient literature and an ancient architecture. It is a country which, whatever may have been the origin of its own civilization, helped to civilize the majority of the countries of the monosyllabic languages—Ava, Tibet, Siam, and (more than is generally believed) China. To the Brahminic and Buddhist religions India stands in the same relation as Arabia does to Mohammedanism.

In all Indian investigation we must bear in mind that there is one native and at least two foreign elements. Of the latter, one is that of the populations akin to the Nepalese and Tibetans whose area at one time reached the Ganges. The other is that of the speakers of the Sanskrit language, whoever they were and whensoever they came. According to some, they were originally strange to the north as well as to the south of India, whilst from the *south* every one excludes them.

The languages wherein the Tamul character is undoubted are the Tamul Proper, the Kanara, the Telinga, the Tulava, the Malayalam, and the Coorgi forms of speech (all in the south); along with most of the dialects of the hill-tribes, one of which, the Rajmahal mountaineers, lies as far north as the Ganges, and within 100 miles of the most southern of the monosyllabic languages, *i. e.*, the Garo.

The languages wherein the Sanskrit elements make the original Tamul character doubtful, are the Punjáb, the Multán, the Sind, the Gujerati, the Rajputana, the Hindi, the Bengali, and the Udiya forms of speech.

CLASS IV.—THE OCEANIC STOCK.

Area.—The Peninsula of Malacca; the Islands of the Indian Archipelago, Chinese Sea, and South Sea; Madagascar, New Guinea, Australia, Van Diemen's Land; *i. e.*, Islands or Peninsula; whence the term *Oceanic.*

Primary Divisions.—(1.) Amphinesia; (2.) Kelænonesia.

Physiognomy.—When Amphinesian, more Mongol than African; when Kelænonesian, more African than Mongol.

Language.—When Amphinesian, with patent and recognised affinities to the Malay; when Kelænonesian, with Malay affinities fewer and only partially recognised.

The Turk group illustrates the diffusion of man over a *continent;* the group before us the distribution of man over the *ocean.* The spread of a population over a continent is *continuous;* its spread over an ocean *interrupted*, or, at any rate, liable to interruption. Thus Gaul, most probably, began to receive a population as soon as the parts in contact with it were full. Britain, on the other hand, may have remained a solitude for centuries and millenniums

after Gaul had been over-peopled. Unless we imagine the first canoe to have been built simultaneously with the first demand for water transport, it is as easy to allow that a long period intervened between that time and the first effort of seamanship as a short one. Hence the date of the original populations of *islands* is not in the same category with that of the dispersion of men and women over *continents.*

Now, great signs of the *interruption of migration* present themselves in the ethnology of the Oceanic Stock; and it is only by the admission of these that the group becomes natural—these and the evidence (often obscure) of language, along with the phenomenon of transitional, or intermediate, forms.

AMPHINESIANS.—These fall into

1. *Protonesians*, or occupants of the Indian Archipelago and Chinese Sea, Sumatra, Borneo, Java, Moluccas, Philippines, &c.; the names being derived from πρῶτος, *first*, and νῆσος, *island*, these being the islands *first* occupied from the Continent. The chief populations here are Malays, Dyaks, Javanese, Bugis, and Philippine Islanders.

2. *Micronesians* of the Caroline and Marianne Islands.

3. *Polynesians*, of the South Sea Isles, in general, from the Sandwich Islands to New Zealand, from the Fijis to Easter Island.

4. *Malagasi* of Madagascar.

KELÆNONESIANS.—1. Papuans of New Guinea; Louisiade, New Hebrides, Tanna, Mallicollo, and New Caledonia; 2. Tasmanians; 3. Australians.

Κελαινὸς, *black; ἀμφὶ, about, around.*—A reference to the map will now explain the nomenclature. Polynesia is considered to have been peopled from Southern Micronesia, Micronesia from the north-eastern part of Protonesia (*i. e.,* from the Philippines, *via* Lord North's Island, the Pelews, &c.) If so, the Amphinesia migration laps *round* the Kelænonesian, which is deduced, for Australia, from Timor, for New Guinea, from the Arru Isles. Tasmania has such remarkable affinities with the Papuan Islanders, that even there the population seems to have come *round* Australia rather than across it. The Kelænonesian civilization is far lower than that of the Amphinesian. Thereof much of the Protonesian part is Mohammedan, a portion Christian, a portion Brahminic, a portion still Pagan. There is also more than one Protonesian alphabet, *e. g.,* the Batta, the Rejang, the Lampong, the Javanese, the Tagala. In most of the Protonesian islands, as well as in the Malaccan Peninsula, there are certain wild tribes, many of which are blacker in skin than the ordinary Malay, Javanese, Dyak, &c. These may be called the *Negritos* of the Malay, or Amphinesian area. In no case where their language has been examined has it been found to be Kelænonesian; nor yet has it been found to differ from the Protonesian dialects of the parts around it more than the Protonesian dialects differ from each other. The generality of writers have separated these from the Malays; some connecting them with the Papuans or Australians. The present writer does not do this. He sees in them only so many members of the ordinary Protonesian group in a ruder and more primitive state. Nevertheless, it was when this state was general, and the ordinary colour of the Protonesians darker, that he believes the migration by which New Guinea and Australia were peopled to have taken place.

In the Fiji islands, the Papuan and Polynesian characters are intermixed, just as if the stream of population that went round Kelænonesia and the extreme Kelænonesians met. The Papuan is one of the least known sections of mankind.

CLASS V.—AMERICANS.

As long as the north-western parts of America were so imperfectly known as they were till within these last few years, the origin of the American population was uncertain; inasmuch as the Red Indians and the Eskimo on the *eastern* side of the Continent stood in strong contrast to each other; the transitional or intermediate forms having been obliterated. We no sooner, however, study the tribes of Russian America and the Oregon, than all such contrasts disappear. The Eskimo of the *west* graduates into the Indian of the *west.* Neither are there wanting direct proofs of philological affinity between the languages of the parts in question and those of the Tungûs, Peninsulars, and Ugrians.

The classification of the divisions and sub-divisions of the American group (a group of value yet undetermined) has yet to take its final form. Provisionally, however, we have the following arrangement:—

Eskimos in Greenland, Labrador, the coasts of the Arctic Sea, Russian America, the Aliaskan Peninsula, the Aleutian Isles, and the extreme north-east of Asia. *Kolúch* in the parts about Sitka, with affinities to the Eskimo on the one hand, and, on the other, to the *Athabaskans*, whose area subtends that of the Eskimo, and reaches from the Pacific to Hudson's Bay. The chief divisions of the Athabaskan group are the Chepewyans, the Beaver, Strong-bow, and other northern Indians, the Takulli, the Sikanni, the Sussees, the Loucheux, the Kenays, to which we may add outlying members as far south as Mexico, viz.: the Kwaliokwa and Tlatskanai on the Californian frontier, the Navahos, and Jecorrillas, and Apatches of California and Mexico. No group has its members lying further north and south of each other than the Athabaskan, some being within the Arctic Circle, some within the Tropics, the southern members isolated. Of equal magnitude with the Athabaskan group is—

The Algonkin, to which the majority of the Indians of the United States are referable, some as far north as Labrador, some as far south as Tennessee. The Delawares, Ojibways (different from the Athabaskan Chepewyans), and more than 30 other tribes are Algonkin.

The Iroquois group contains the Oneydas, Hurons, Wyandots, Senecas, Cayugas, Mohawks, &c.

The Sioux, the Ioways, Minitarees, Osages, and numerous tribes of the parts between the Mississippi and Rocky Mountains.

The *Woccons, Catawbas, Cherokees, Chochtas, Creeks and Caddo,* have all Sioux and Iroquois affinities, and may probably have, under some future classification, to form with those two groups one large class.

Paducas.—This means the tribes that speak languages akin to the Comanch, numerous in Oregon, California, Texas, and Mexico.

Texas and the south-western parts of the older states give us a vast mass of small tribes still requiring classification, Uche, Coosadas, Alibamas, Taenzas, Pascagoulas, Colapissas, Biluxis, Chetimachas, Humas, Tuncas, Pacanas, Natchitoches, Adahi, Opelusas, Attacapas, Natchez. Neither are the Riccarees, Pawnees, and Ahnenin (Fall Indians), further north classed.

In New Caledonia, Oregon, and California, we have

On the coast—The Haida, Chemmesyan, Billechula, Hailtsa, Chinuk, and Nutka tribes.

In the interior—The Atnas (Shushwah), Cutanis, and Sahaptins.

Add to these Jakons, Molele, Cayûs, Kalapuyas, Lutuami, Saintsila, Shastis, Palaks, &c.

In California a large portion of the Indians is either Athabaskan or Paduca. Still, there are several unclassed tribes. In the direction of New Mexico, and in New Mexico itself, we have the so-called *Puebla* Indians, partially unclassed—Moqui, Zuni, Taos, &c. In Old California, we have the Cochimi and Pericu tongues. Sonora gives us the Pimo and Coco-maricopas, the Opata, Ciri, and Jaqui languages. Further inland lie the Cora and Tarahumara, leading to

Mexico, where the chief form of speech is the Aztek, not without many others (the Tarasca, the Otomi, &c.) around it. In Central America the Maya is preponderant—also with numerous minor languages around it. In Nicaragua the Mexican reappears with the Dirian, Chontal, and other forms of speech, lately illustrated by the researches of Squier in its neighbourhood. The Moskito, the Bayano, &c., lead us to the South American, where the Muysca section takes the same prominence in New Grenada that the Aztek did in Mexico, the Maya in Guatimala, and the Quichua, will take in Peru.

These give us the *maximum* amount of American civilization; a civilization which we either infer from the architectural and other remains spread over the Mexican and Peruvian areas, or else find described in the writings of the early Spanish conquerors. Undoubtedly, these supply us with some strong contrasts to the rudeness of the ordinary American Indian of the lake districts and prairies. They are differences, however, of degree rather than kind, as may be seen by taking the chief characteristics of the Mexican and Peruvian culture, and asking how far they appear in a rudimentary form elsewhere. Assuredly, some of the most important will be found amongst tribes of far less historical prominence than the ones in question. The existence of such an empire as Montezuma's is, undoubtedly, a measure of the Aztek civilization. Yet the obscurer one of Powhattan in Virginia exhibited an equal amount of organization. The phrase *picture-writing* applies to some of the imperfect historical records of the same country. Yet it is but the daub of the Pawni, or Algonkin in an improved form. The agricultural and metallurgic industry of the Anahuac and Cordillera has its origin quite as much in the physical conditions of the soil and climate as in any original intellectual superiority on the part of its occupants; besides which, it is approached by that of the Puebla Indians. The Mexican arithmetic has long commanded attention. It not only gives us a simple term for 20, but also one for 400 and 8000. Much stress has been laid upon this so-called vigintesimal system. There is reason, however, for referring it to a very common-place origin. *Twenty* = *man* (*i. e.* ten fingers and ten toes). *Twenty* men made the first division of the Mexican army—say a *company;* 20 of these made (say) a *regiment;* 20 regiments an *army*. This we infer from the symbols for 20, 800, and 4000, which are also those of the three military divisions just enumerated. We cannot, with such a fact as this before us, credit the Mexicans with having an extensive multiplication table. They may have been unable to count the intermediate numbers between 40 and 400, or even between 20 and 40. Another line of argument has helped to isolate these civilizations. Wherever similar characteristics appear they have been called, off-hand, Mexican or Peruvian, as the case might be. Nevertheless, the truer inference from the fact of certain architectural remains, &c., being found over a vast tract of country is, not that there has been a certain amount of conquest or colonization, but that more divisions of the American population than one have worked in the same way on similar materials.

Language, too, has helped to isolate. The Otomi tongue has long been known to be eminently monosyllabic. But there are others in the same category, *e. g.* certain Athabaskan dialects, the Attacapa, &c.

Again, many American nations flatten the skull artificially, and are known to do so; others are found with it flattened, but are not known to flatten it. Hence, we get the possibility of such a phenomenon as *naturally* flat crania, a phenomenon on which many authors insist. If their view be accurate, it gives us a physical distinction of great value, amounting, perhaps, to a specific difference. The *natural* character, however, of the skulls in questions is, as yet, unproved. Such are some of the *differentiæ*—physical and moral—between the more extreme American populations; and it must be admitted that they cannot all be explained away without a considerable amount of assumed influences. The more, however, these are studied, the more probable they appear. The more, too, we go into the details of the division itself, the more we find transitions and intermediate forms.

The great South American families of which the limits are the most defined are—1. The Quichuas. 2. The Caribs. 3. The Guarani; the Chaco, the Pampa, and the Chileno groups being of somewhat less, though still of considerable, magnitude.

1. The *Quichua* section follows the line of the Andes from the equator to S. Lat. 28., extending, at one point, as far east as Tucuman.

2. The *Caribs* have the same prominence in Venezuela that the Quichuas have in Peru and Bolivia. They extend from New Grenada to French Guiana. In Trinidad, part at least of the early population was Carib, as it was in the Antilles.

The Quichuas are mountaineers. The Caribs seem to have followed the courses of the rivers—being *fluviatile* so to say. More fluviatile, however, than the Caribs are

3. The *Guarani*. Guarani or Tupi forms of speech are found at the mouth of the Amazons, also at the mouth of the river Plata, also on the intermediate coast. In Entre Rios, Corrientes, and Paraguay, it spreads inland. On the watershed of the Amazons and Plata, in the province of Santa Cruz de la Sierra, the Chiriguanos, Sirionos, and Guarayos, are Guarani. Again, on the Napo and Putumayu, the Omaguas are Guarani also. Hence, the best provisional view that we can take as to the diffusion of so important a stock, may be to consider the Siriono and Guarayo districts as the original localities. These are common to two river-systems; so that, starting from these, the Omagua branch may have reached the Amazons, whilst the Guarani reached the Parana and Uruguay rivers. Still the view is only provisional.

Next to the Quichuas, the Guaranis give us some of the most civilized tribes of South America. On the other hand the *Mundrucu*, of the middle Amazons, can be shown by their language to be Guarani; the *Mundrucu* serving as the very type and standard of savage wildness. When a *Mundrucu* has slain an enemy he cuts off his head, extracts the brain through the occipital *foramen*, washes the blood away, fills the skull with cotton, and then converts the whole into a kind of mummy, by drying it before the fire. The eyes he gouges out, and he fills up the orbits with colouring matter. Thus prepared, the head is placed outside his hut. On festive occasions it is placed at the top of a spear. Such is the history of the head of an enemy. Those, however, of friends and relations are preserved and kept, though with certain differences of detail. Thus on certain days dedicated to the obsequies and memory of the dead, the widow of the deceased takes a skull, seats herself before the cabin, and indulges either in melancholy lamentations, or in fierce encomium; the assembled friends meanwhile dancing round her.

The Chileno-Patagonians. The name is more expressive than convenient. It indicates, however, by its very composition, the magnitude of the group to which it applies. When we get into Chili, we arrive beyond the limits of the Quichuas and a new family makes its appearance, extending over Chili; over the whole of the country S. of the river Plata, over the islands of the Chiloe Archipelago, and Terra del Fuego. Its divisions comprise, (*a*), the Chileno (or Araucanian) Indians; (*b*), the Pampa Indians; (*c*), the Patagonians; (*d*), the Fuegians.

The range of differences in respect to physical form is wide in this group; the range of differences in respect to the geographical conditions under which they are found, being also wide; *e. g.*, there are the Andes of Chili, the level

plains of the Pampas, and the insular character of the parts about Cape Horn; not to mention the fact of South America extending farther in the direction of the Antarctic Circle than any other part of the world.

In contrast to the large areas occupied by single families, we have, in South America, as elsewhere, small districts with a multiplicity of distinct divisions and subdivisions. One of these lies in the north, on the Orinoco and Amazons, in contact with the Carib area. Hence, we find the Maypuri, the Saliva, the Achaguas, and the Ottomakas, &c. On the Uapes only, Mr Wallace enumerates the Queianas, the Tarianas, Ananas, Cobeu, Piraiarara, Pisa, Carapana, Tapura, Uaracu, Cohidias, Tacundera, Tacami, Miriti, and Omãnas. These will probably turn out to be Carib, the import of the word as a class-name being enlarged.

Surrounded more or less by the Guaranis and occupants of Brazil, come the Botocudos, Canarins, Goitacas, Machacari, Patachos, Camacans, Matali, Cacriabas, &c., &c., falling into divisions and sub-divisions. Add to these the Indians of the missions of (*a*) Moxos and (*b*) Chiquitos; the Indian of the Eastern side of the Andes (Juracares, Mocetenes, Tacanas, and Apolistas); the Indians of the Chaco, chiefly Abipoman. To this class belongs, with others, the Abiponians Proper, the Mbocobi and Toba, the Lenguas, the Payaguas, the Matagayes, the Guaycurus, perhaps the Charruas, known at present only in fragments, whole sections of it being either extinct or incorporated. The original divisions, however, were as follow:—

1. The Charruas Proper; 2, the Chagos; 3, the Chanâs; 4, the Guenoas; 5, the Martedanes; 6, Niboanes; 7, the Yaros; 8, the Minoanes; 9, the Caaiguas; 10, the Bagaez; 11, the Tapes. Of these the Chanâs and Niboanes inhabited, at the arrival of the Spaniards, the islands of the Uruguay, at the junction of the Rio Negro.

One of the most remarkable, and, at the same time, isolated, populations of South America are the

Warows.—Their occupancy is the Delta of the Orinoco, a swamp; as is a considerable portion of the sea-coast to the south of it. If it were not for the straightness of his hair, the Waraw (writes Sir Robert Schomburgh) might be taken for a negro. Doubtless he is dark-skinned, but I do not imagine that he has the negro lip. His skin is dark, and dirt gives intensity to its natural darkness; for the Waraw is uncleanly, even for an Indian. His language is certainly unintelligible to all his neighbours; neither has it been placed in the great Carib class, wide and capacious as that class is; nevertheless, it is far from being wholly isolate. It has miscellaneous affinities, and plenty of them; but the most notable characteristic of the Waraw is his industrial activity as a boat-builder. This furnishes nearly the whole of the Demerara with canoes. They are made either of the *Cedrela odorata*, or of a tree called Bisi, and are sometimes fifty feet long and six feet broad.

When a suitable tree has been found, the Waraw builds a hut in its neighbourhood, which he occupies as long as the boat is being built. The floor of the hut must be some feet above the level of the ground, and this is effected by selecting a spot where the ita-palm grows in thick clusters. This is docked to the requisite height, the root and a part of the trunk being left standing. The trunk of the maneca-tree is then cut into planks and made into a floor. Clay is laid on the floor, and a fire kept burning on the clay. The *Manicaria saccharifera* supplies the thatch.

Raleigh came in contact with the Waraws, whom he describes under the name of *Tivitivas*, adding that they fall into two divisions—the *Ciawani* and the *Arumeate;* that "they are a goodly people, and very valiant;" that, "in summer, they have houses on the ground as in other places. In winter they dwell in trees, where they build very artificial towns and houses; for between May and September the river of Orinoco riseth 30 feet upright, and then these islands are overflown 20 foot high above the level of the ground, saving some few raised grounds in the middle of them; and for this cause they are enforced to live in this manner." The undoubted peculiarities of the Waraws have been exaggerated; and they have been described as men who *live in trees*,—as *arboreal varieties* of the human species,—even as *arboreal species* of the *genus Homo.*

For South America I give D'Orbigny's classification, premising that I do not find it coincide with the divisions deduced from the comparison of the South American languages.

South American Indians.—Colour yellow, brown, or copper-red; height variable; hair thick, coarse, black, smooth and long; beard thin, coarse, black, never wavy, late in making its appearance; chin short; eyes small, deep-set; jaws prominent; teeth nearly vertical; eyebrows prominent.

1. *Primary divisions, or races (so-called)*—

A. *Ando-Peruvian.*—Colour olive-brown; stature low; forehead either depressed or but slightly vaulted; eyes horizontal, never *bridés* at their outer angle.

B. *Pampa.*—Stature often considerable; forehead vaulted; eyes sometimes *bridés* at the outer angle.

C. *Brazilio-Guarani.*—Colour yellowish; forehead not retreating; eyes oblique.

A. *Ando-Peruvians*—

a. Peruvian branch.—Colour deep olive-brown; form massive; trunk long in proportion to the limbs; forehead retreating; nose aquiline; mouth large; physiognomy sombre.—Aymara and Quichua Peruvians.

b. Antisian branch.—Colour varying from a deep olive to nearly white; form not massive; forehead not retreating; physiognomy lively, mild.—Yuracares, Mocétènès, Tacanas, Maropas, and Apolistas.

c. Araucanian branch.—Colour light-olive; form massive; trunk somewhat disproportionately long; face nearly circular; nose short and flat; lips thin; physiognomy sombre, cold.—Indians of Chili and the Chonos Archipelago. The Fuegians.

B. *Pampas*—

a. Pampa branch.—Colour deep olive-brown, or *maroon;* form herculean; forehead vaulted; face large, flat, oblong; nose short; nostrils large; mouth wide; lips large; eyes horizontal; physiognomy cold, often savage.—Indians of the Chaco and Patagonia.

b. Chiquito branch.—Colour light olive; form moderately robust; mouth moderate; lips thin; features delicate; physiognomy lively.—Indians of the Mission of Chiquitos.

c. Moxos branch.—Form robust; lips thickish; eyes not *bridés;* physiognomy mild.—The Indians of the Mission of Moxos.

C. *Brazilio-Guarani.*—A simple branch.—Colour yellowish, with a slight tinge of red; form massive; height moderate; face circular; nose short and straight; nostrils narrow; mouth moderate; lips thin; eyes oblique; eyebrows prominent; features delicate (*efféminés*); physiognomy mild.—Guarani, Caribs (?), and all the unplaced tribes of Paraguay, Brazil, the Guianas, and Venezuela (?).

From the parts about Cape Horn, we return to the western frontier of the Ugrian area, this being the frontier where European and Asiatic ethnology join.

B.

CENTRAL AND SOUTHERN EUROPEANS.

European ethnology is peculiar,—we may call it *minute ethnology.* The main divisions are known from history. So are their chief characteristics. Hence the points that command attention are certain of the finer shades of difference.

The general and leading facts that, in the case of such tribes as the Polynesian, the American, or the African, have to be collected as so many fresh points of information, are already known. As compared with Polynesia, America, or Africa, Europe is but a portion of Asia. Nevertheless its physical conditions claim consideration. No part of Europe lies between the tropics; so that the luxuriance of a spontaneous and varied vegetation, with its pernicious tendencies to incline the habits of its population to idleness, is wanting. The rank and rapid growth of the plants which serve as food to men and animals, and which dispense with labour, nowhere occurs. Few parts come under the class of steppes, or at most but imperfectly approach their character. In Asia, the vast table-lands of the centre, occupied by the Turks and Mongols, have ever been the cradle of an active, locomotive, hungry, and aggressive population. And these have ever had a strong desire to possess the more favoured areas of the south, and have conquered them accordingly. The Luneburg Heath, and parts of Russia, are the nearest resemblances to the great steppes of Mongolia and Independent Tartary; but they are on a small scale. In Russia, where the land is flat and level, the ground is also fertile, so that agriculture has been practicable, and (being practicable) has bound the occupant to the soil, instead of mounting him on fleet horses to wander with his flocks and herds from spot to spot, to become a shepherd by habit and a warrior by profession.

Europe is narrowest in its northern parts. This has had the effect of limiting those populations of the colder climes, whose scanty means of subsistence at home incline them to turn their faces southwards with the view of conquest, and supply them with numbers to effect their purpose.

Its diameter from north to south is less than its diameter from east to west. This has kept the mass of its population within a similar climate, or, if not within a similar climate, within a range of temperature far less wide than that which separates the African, the American, or the Asiatic of the northern parts of their respective continents, from the Hottentot of the Cape, the Fuegian of Cape Horn, and the Malay of the Malayan peninsula.

In no country are the great levels more broken by mountains, or the great mountains more in contiguity to considerable tracts of level country. The effect of this is to give the different characters of the mountaineer and the lowlander more opportunity of acting and re-acting on each other.

In no country are the coasts more indented. We may look in vain for such a sea-board as that of Greece elsewhere. The effect of this is to give the different characters of the sailor and landsman, the producer and the trader, more opportunity of acting and re-acting on each other.

The greatest rivers fall into seas navigable throughout the year. Contrast with this the great rivers of Asia—the Obi, the Lena, the Yenesey, and others, which for the purposes of navigation are useless, falling as they do into an Arctic sea.

Our greatest river, the Danube, runs from east to west. This ensures a homogeneous character for the population along its banks. Contrast with this the Nile, the Mississippi, and the Yenesey, in all of which the simple effect of climate creates a difference between the populations of the source and the embouchure. The great rivers of China do the same as the Danube; but the Danube differs from them, and from all other rivers running in a like direction, by emptying itself into an inland sea; a sea which gives the opportunity of communication not only with the parts north and south of the rivers which fall into it, but with those to the east of it also. The Hoang-ho and Kiang-Ku empty themselves into an ocean that, in these days of easy communication, leads to America, but which, in the infancy of the world, led to a coasting-trade only, or at most to a large island—Japan. The Baltic and Mediterranean have,—the one Africa, the other Scandinavia, to ensure their being put to the uses of trade.

Add to these the relations of south-eastern Europe to the countries watered by the Nile, the Tigris, and the Euphrates in other words, in investigating the conditions under which European civilization evolved itself, remember those of the eastern extremity of the Mediterranean.

There is another point which stands out more prominently in European ethnology than elsewhere. European history goes far back. Doing this, it tells us of great changes—changes which we may *assume* elsewhere, but which we *know* to have existed in Europe. What if these go to the extinction of some stock, group, or family? A great complication is introduced. The extinction has more meanings than one. It often means absolute obliteration. It oftener, however, means no more than the abolition of the outward and visible signs of ethnological difference. A negro marries a white. In the fourth, fifth, sixth, or seventh generation, as the case may be, his descendant is, to all intents and purposes, a white man. Yet the negro blood is not extinguished. It exists, though in a small proportion. Again, a Cornishman loses his native language and speaks English as his mother tongue. Many generations before he did this he differed from the Englishman in speech only. Is his British blood extinguished? No. The chief sign of it has been lost; that is all—so that, stocks may be obliterated, may intermix, or may lose their characteristics. To determine what existing populations are descended from the populations of the classical times, and to give to existing populations their ancestors during the same period, is a business which continually devolves upon the European ethnologist, more rarely upon the ethnologist for Asia, never upon the ethnologist for Polynesia or America.

Physically, the European populations are alike, the differences lying within narrow limits. In language the lines of demarcation are broader.

The European physiognomy is generally considered to be Caucasian as opposed to Mongolian, *i. e.* Caucasian, in the wide, Blumenbachian, and inconvenient sense of the term. And this it is in the southern and in the more cultivated parts of Central Europe. But it is by no means so generally. I do not say that truly Mongolian faces are common anywhere. I *do* say, however, that the Slavonic physiognomy approaches the Ugrian, and the Lithuanian does so still more; also that the Malay features (sub-typically Mongol) are common in the Alps, the Pyrenees, the ruder parts of Germany, Ireland, Scotland, Wales, France, and England.

The languages fall into four divisions. The first two contain two unplaced forms of speech. The third contains a form of speech which has lately been incorporated with the fourth, but only lately and only partially. The fourth contains a group of languages long and universally admitted not only to be allied, but to be closely allied:

1. *The Basks.*—Their language isolates the *Basks.* Their locality is the western Pyrenees, the north of Spain, and the south of France. Here it is where, although in the towns, like Bayonne, Pampeluna, and Bilboa, the population is French or Spanish, the country people are *Basks* or *Biscayans*—Basks or Biscayans not only in the provinces of Biscay, but in Alava, Upper Navarre, and the French districts of Labourd and Soule. Their name is Spanish (the word having originated in that of the ancient *Vascones*), and it is not the one by which they designate themselves; though, possibly, it is indirectly connected with it. The native name is derived from the root *Eusk*, which becomes *Eusk-ara* when the language, *Eusk-kerria* when the country, and *Eusk-aldunac* when the people are spoken of; so that the Bask language of the Biscayans of Bisca

is, in the vernacular tongue, the *Euskara* of the *Euskaldunac* of *Euskerria*. That the Euskara is no new tongue may be inferred from the fact of its falling into dialects, which Humboldt limits to three, whilst others extend them to five or six. The Biscayan proper is spoken in the country of the ancient Autrigones and Caristii, and it has been proposed to call it the *Autrigonian*. It has less correctly been called *Cantabrian*, and this is the name which the national taste best likes; for a descent from the indomitable Cantabrian, who so long and so successfully spurned the yoke of Rome, and who transmitted the same spirit and the same independence to the Asturian, is creditable enough to be claimed. Nor is the claim unfounded, since, in all probability, the ancient Catabria included some of the ancestors of the Euskaldunac. The Guipuscoan is the western Biscayan. The Laburtanian is the Euskarian of France, spoken in the parts about St Jean de Luz; and which, in the district of Soule, is supposed to fall into a sub-dialect. Even as the mother-tongue of the present Welsh was, originally, the language of the whole of Britain, so was the mother-tongue of the present Bask the language of the whole of the Spanish peninsula. The generic name for this is *Iberian*, so that, assuming a certain amount of intermixture between the invading Romans and the aboriginal inhabitants, the present Spaniard, though Latin in speech, is, more or less, *Iberian* in blood. So are the south-western French, inasmuch as the old Iberian reached the Garonne, perhaps the Loire.

2. *The Skipetar* or *Albanians*.—Their language isolates them, though many hold that it can be connected with those of the fourth class. Albania is their occupancy. The testimony of travellers to their belonging to the fair-complexioned and grey-eyed populations is pretty general, although Skene gives the Mirdite tribe a swarthy skin and black eyes. The evidence, too, as to their bulk and stature varies; some writers giving them spare, light, and tall forms, others making them shorter and more square-built than the Greek. That the eye has less animation, and the countenance less vivacity (in other words, that the Albanian is heavy featured as compared with his quick-witted neighbours) is certain. Both the men and women are hardy, and expose their bodies freely to the atmosphere, accustoming themselves to an out-door life amongst their flocks and herds, and dwelling, when in-doors in rude huts. Like the Swiss, they willingly let out their valour and hardihood in military service; and the best and most unscrupulous soldiers of the Sultan are those recruits, who, partly by force, partly by pay, are brought from Albania. Hence we find Albanians far beyond the pale of Albania; in Greece, in Thrace, in Asiatic Turkey, in Egypt, and even in Persia. The tribes too, amongst themselves, indulge in the right of private quarrel, rarely rising to the dignity of warfare, but more like the old border feuds between England and Scotland. Some of the Skipetar are Mohammedans, some Roman Catholics, some Christians of the Greek church. These are the modern representatives of the ancient Illyrians. Skipetar blood must be found far south of the present Skipetar area, even as Bask (Iberic) blood is to be found in the non-Iberic parts of Spain and Portugal and France.

3. *The Kelts*.—By raising the value of the class called Indo-European, a class based upon philological rather than physical grounds (for which see Notes on LANGUAGE), the Kelts (= the Welsh, Bretons, Gaels, and Manxmen) can be placed in the same division with the

4. *Sarmatians, Germans, Latins, and Greeks*, who are Indo-European (*q. v.*) in the strictest sense of the term. *Sarmatian* means *Slavonic* and *Lithuanic* collectively. The great historical nations of Europe belong to this class. For the relations of the speakers of the Sanskrit language see LANGUAGE (*Notes*).

C.

AFRICANS AND SOUTH-WESTERN ASIATICS.

A return to the south-western parts of Asia leads us to the ethnology of Africa, which begins in Syria and Mesopotamia; the populations akin to the Arab being (in the opinion of the present writer at least) African rather than Asiatic; at any rate, transitional or intermediate.

The populations speaking languages akin to those of the Bible and Koran (the Hebrew and the Arabic) are termed

A. *Semitic*.—This group contains,

In Asia, the Syrians, Assyrians, Babylonians, Phœnicians, Ammonites, Moabites, Ishmaelites, Edomites, Samaritans, Jews, along with their colonies, &c., of antiquity; of modern populations, the Arabs, the Jews, the Kaldani (of Kurdistan), the Arabs, &c.

In Africa, the Abyssinians of the province of Tigré (*Christian*), the Abyssinians speaking the Amharic language (*Christian*), the Gafat Abyssinians (*pagan*).

Sufficiently akin to these to have become called *Sub-Semitic* are the Amazirgh or Berber, and Copt or Ægyptian, tribes. With the modern Copts the hair is black, crisp, or curled; the cheek-bones prominent; the lips thick; the nose somewhat depressed, nostrils wide; complexion brown or yellowish; eyes oblique (?); frame fleshy; physiognomy heavy.

With some of the Berbers—*e. g.*, the Tuariks of Wadreag—the hair and skin are nearly the hair and skin of the negro. With others—the Amazirgh of the ancient Mons Aurasius—the complexion is so light as to have engendered the doctrine that they are descended from the Europeans who, under Genseric, sacked Carthage.

We approach the negro types in the division for which the name

B. *Nilotic* is suggested, its area being the drainage of the Upper and Middle Nile. Of the four chief Nilotic groups (1 and 2), the Nubians and Bishari approach the Copts, (3) the Agows, the Abyssinians, (4) the Gallas having both Semitic and Kafre characteristics. The colour is often brown rather than black, the frame spare, the nose straight or aquiline, lips moderate, hair long. In respect to language the Agow dialects are Sub-Semitic. Hence, whilst the Semitic populations are extreme—*i. e.*, Asiatic or European rather than negro—the Nilotic are transitional. Several of the Nubian tribes are truly negro, at least the languages of Kordofan and Darfur belong to this class. For the philological import of the term *Semitic* see LANGUAGE (*Notes*); also for that of

C. *Kafre*, the name of the next group.

The Kafre area extends from the parts north of the equator to the Hottentot frontier, and that on both sides of the continent; the tribes of the higher levels and the more southern areas departing furthest from the negro type; those of the coast, the alluvial tracts, and the parts nearest the equator approaching it the closest. In many cases the Kafre physiognomy is absolutely negro. The *eastern* Kafres, of Mozambique, Zanzibar, &c., are conterminous with the southern Gallas; the *southern*—those of the Cape—with the Hottentots and European colonists; the *western*—of Benguela, Angola, Loango, &c.—with the negroes of the parts between the Niger and the Gaboon, members of a class pre-eminently, but not exclusively, nor yet to the exclusion of other classes.

D. *Negro*.—Skin black, hair woolly, lips thick, nose depressed, jaw protruded, forehead retiring, proportions of the extremities abnormal. Such is the extreme type. Add to this that the civilization is low, and the area chiefly consists of lowlands, coasts, and the deltas of rivers, rather than of elevated plateaux or mountain ranges. When the occupancies are of this latter kind the physiognomy approaches that of the Semitidæ, the language in many cases being negro, or like that of the nearest tribes.

With the negro branch of the African division it is convenient to begin with the part where the black tribes touch the south-western Amazirghs and Moors. This means the parts about the Senegal.

The Wolofs.—Skin black, conformation negro, religion pagan rather than Mohammedan. Large portion of their area the valley of the Senegal.

The Mandingos.—Less dark than the Wolofs, negro, original paganism largely replaced by Mohammedanism. Large portion of their area the valley of the Gambia.

The Fulahs.—Skin brown rather than black, form less negro and more Arab than that of the Mandingos and Wolofs, creed largely Mohammedan. Area elevated, the watershed between the Gambia and Senegal.

With all these populations the civilization is comparatively high.

The languages unequivocally related to the Mandingo extend as far south and east as the Ivory Coast; for the strip which extends along the sea from Cape Mount to Cape Palmas, and which is occupied by tribes akin to the Krumen, we (after several doubts) subordinate to the Mandingo area, or rather we make both the Kru and Mandingo group members of the same large class. On the other hand, a portion at least of the Kong range is Mandingo; indeed, the extremity of this area reaches the Ashanti frontier inland, and the Fanti frontier on the Gold Coast; these two names belonging to one and the same class, a class conveniently called

Inta.—To this belong the Booroom, Aowin, Amanahea, Affutu, Ahanta, and Odzhi forms of speech. Mohammedanism decreasing, fetichism predominant.

The Gha or Akra, occupants of the parts about Cape Coast Castle, speak a language said to be unintelligible to the Fanti, but with numerous Fanti, as well as other affinities.

The Dahomey tribes occupy the *Slave Coast;*

The Benin, or Moko, the delta of the Niger along with

The Ibos.—These are all subdivisions of some single group of unascertained but no very high value. The influences of Mohammedanism are here at the *minimum;* snake worship and human sacrifices being common; circumcision being common also. The *Bonny* tribes form a division of this class.

The Mahas, who reach as far inland as the Kong range, are Dahomey tribes.

At the back of the Benin and Ibo countries inland, lie three allied groups—allied also to the groups just enumerated—viz.:—

The Yorruba (*or Aku*), *the Kouri, and the Tapua* (*or Nufi*).—The Yorruba and Tapua populations lead to those of the interior.

In the parts about the *Old* Calabar river the type (of *language* at least) is considered to change. Such being the case, we may return to the Wolof area, and go over some portions of the ground again for the sake of certain *minutiæ* which the *general* sketch hitherto given has prevented us from noticing.

The three great classes of the Wolofs, Fulahs, and Mandingos, by no means exhaust the populations between the Senegal and Cape Mount. About Cape Verde, surrounded by Wolofs, lie the Sereres. Further inland, separated from the Sereres by Wolofs, and in contact with both Fulahs and Mandingos, lie the Serawolli. The languages of each of these divisions have miscellaneous affinities with each other, and the three leading tongues just named. Perhaps, they are most like each other, next like the Fulah and Wolof, least like the Mandingo.

From the Casamança to the Sherbro, the languages of the coast are all *other than* Mandingo, Fulah, or Wolof Proper. They differ, too, from each other. Some have been subordinated to other groups, though only by certain writers. The general phenomenon is the appearance of several mutually unintelligible and by no means visibly allied tongues within a comparatively small area; these being —*The Felúp*, the *Banyon*, the *Papel*, the *Balantes*, the *Biafares*, the *Bissago Islanders*, the *Nalu* and the *Sapi*, the languages akin to the *Timmani* and *Bullom*, south of which the Mandingo group shows itself on the coast.

Again,—east of Cape Palmas we have the imperfectly known languages of the Ivory Coast, with miscellaneous affinities to the Mandingo, Fanti, &c.

Amongst the tribes thus enumerated the Fulahs stand most by themselves in physical form, being brown rather than black. In civilization the Mohammedan Mandingos equal them. In natural vigour and spirit the Wolofs and Krumen are honourably distinguished. Fetichism and slave-dealing take their worst forms in Dahomey. For simple rudeness of habits the Felúps and the smaller sections like them are most conspicuous. Laying language (which will be considered elsewhere[1]) out of the question, the chief objection to throwing all these into one large group lies in the physical peculiarities of the Fulahs. We must note, however, the extent to which it coincides with certain physical conditions, and remember that we have met it under similar conditions elsewhere, *i. e.* in Abyssinia. The reasons for not carrying this class further south, lie in certain points of language also considered elsewhere. Arguing from the direction in which the leading populations seem to have spread themselves, we may, in a somewhat bold attempt to reconstruct the original *situs* of the northern section of this great western group, not unreasonably hold—that the Sereres, Serawolli, and the minor populations, like the Felúp, &c., are *in situ;* the Wolofs, Mandingos, and Fulahs, that most indent their areas, being intrusive; the first having spread from the Lower Senegal, the second from the Upper or Middle Senegal, the third from the Upper Gambia and the parts south of it. The Timmani seem to have encroached from the north, the Gha from the interior; the Ashanti having also effected large displacements. The Mohammedan Africans use, though sparingly, the Arabic alphabet—the Mandingos being, perhaps, the best scribes and scholars. The Vei (a division of the stock) have a syllabic alphabet of their own, invented by a native lately dead, Doala Bukara. He had seen both Arabic Korans and English Bibles, so that the idea of *writing* sounds was one with which he was acquainted.

South of the Berber and east of the Fulah, Mandingo, Jorruba, and Tapua areas, come the inland populations of the northern tropic, some of the extreme negro type, rude, and wild, and others only subtypically negro, and modified by Mohammedanism. The chief divisions here are philological; the physical differences lying within narrow limits. Neither does anything but language separate them from the western tribes. On the other hand, there are great gaps in the geography.

The *Haussa*, *Timbuctu*, *Adamowa*, *Bornu*, *Begharmi*, *Mandara*, *Mobba*, *Furian* (*Darfurian*), and *Koldagi* (*Kordovan*) groups, of unascertained value, and chiefly philological, lead us across the drainage of the Lake Tshad to that of the Nile, where the phenomena of the Gambia repeat themselves in a very marked manner. There are the analogues of the Fulahs in the mountain districts and plateaux of Abyssinia, those of the Wolofs, Mandingos, and smaller tribes like the Felúp on the alluvial soils. The negroes are chiefly those of the Kordofan frontier, of Sennaar, and of the lower level of Abyssinia—*Shelluk*, *Denka*, *Tumali*, *Shabún*, *Fertit*, *Qamamyl*, *Dalla*, *Doba*, *Gonga*, &c. In Abyssinia some of the languages are decidedly Semitic, *e. g.* Gheez, others Sub-Semitic, as the Agow, with transitional or intermediate forms. In the elevated table-lands

[1] See *Notes* on LANGUAGE.

the skin is brown rather than black, and the features Arab or Persian rather than negro. There are are also features comparatively Arab or Persian, with black complexions. An early Christianity, as well as Mohammedanism, has taken root in Abyssinia. The *Galla*, *Nubian*, and *Bishari* divisions (of unascertained value) give us notable deviations from the extreme negro type—the hair being long, the nose often curved, the face elongated.

On the east coast there is a certain number of tribes yet to be accurately distributed between the Kafre and the Abyssinian stocks, just as on the west there are (in the parts about the Old Calabar river) some similar tribes whose relations to the populations north and south of them are equivocal.

The last division of the African stock are—

E. *The Hottentot.*—With the extreme varieties of this division the physical conformation departs widely from even the negro standard. The stature is low, limbs slight, cheek bones prominent, zygomatic arches bent outwards (giving a Mongoloeid form to the face), hair in tufts, eyes oblique. In the female organs of generation the nymphæ are sometimes enormously developed—the buttocks being steatomatous. The pelvis exhibits a *maximum* difference according as it is male or female—the male being strong and dense, the female light. In both cases the diploe between the bony plates is small in amount, the ossa ilii vertical, the sacrum narrow, the conjugate diameter short. The neck of the thigh bone is short, with an oblique direction. Such, at least, are the results of the researches of Vrolik. The cranium is dolichocephalic, *i. e.*, according to the terminology of Retzius, more remarkable for its fore-and-aft than for its side-to-side diameter. In this it is African rather than Mongol—it being Africa and Mongolia that supply the two extreme forms of the dolichocephalic and brachycephalic cranium. The language contains more than one inarticulate sound, described as the *click*.

The general habits of the Hottentot family are pastoral; the inferior members of it, the Saabs or Bushmen of the *Karroo* country being hunters—in many cases in the still lower condition of the Australian. The Hottentot has a better claim to be considered as a separate species of the genus *Homo* than any other section of our kind. Further remarks on this statement will be found in Language (*Notes*). All that will be done at present will consist in a short notice of the two extremes of the group. The *Saabs* are the lowest in civilization and the smallest in size, their country being the district between the Roggeveld and the middle part of the Orange River—the most unfavoured spot, perhaps, in Africa. Their skin is tawny rather than black, their language either wholly or nearly unintelligible to the Hottentots. The Korana Hottentots continually encroach on them, and hunt them down like beasts. Of the Hottentots of the Cape frontier the Koranas are the best-looking. Their claims, however, to stand as the models of the family are modified by the recent researches of Galton in the parts east of Walvisch Bay, and the explorers of Lake Ngami. The Hottentot tribes reach thus far north, where they are the equals, and, in some cases, the superiors of the Kafre populations in frame and daring. On the other hand, where the external conditions of aliment, security, and freedom are unfavourable, there is a visible degeneracy. The same has been remarked at the Cape. According to Mr Thompson, a division of the Koranas, who lost their herds, rapidly approached the Bushman type. The Griquas are a mixed breed—Dutch and Hottentot.

Such is the classification which, in the opinion of the present writer, best represents the divisions of the human species. He is well aware that the value of the classes is unequal, and that the nomenclature is imperfect. On the other hand, he believes that both the arrangement and the phraseology are sufficient for all questions likely to arise out of our present *data*, and also that they give a good groundwork for future investigations. That they are based upon a certain amount of assumption is clear—in other words, they are more or less hypothetical. In the eyes of several respectable authorities, they assume the chief point in question, viz., the specific unity of *man*, and the division of the species constituted by the men of present and past times into varieties and sub-varieties. What if all these varieties be species, and the species a genus? To this objection the writer will forthwith address himself—premising his remarks by an explanation of the point of view from which he has taken the preceding outline.

1. That all the languages of the earth's surface have had either one common origin, or else been, one and all, largely modified by some single language, he is convinced; due allowance having been made for a large amount of similarity independent of any ethnological connection. This means that a large number of words in different languages will be like each other, not because two or more tongues lent or borrowed certain words, nor yet because they all came from a common mother tongue, but because the human organism, under certain conditions, acts according to certain laws.

2. The similarity between languages, which is not thus explained, is held to be *primâ facie* of a common descent on the part of those members of the human kind that speak them—*primâ facie* evidence, and that of a strong sort.

3. That this *primâ facie* evidence will *not* be over-ridden by the conflicting phenomena of physical and moral differences is the writer's *impression*, an impression that has been forced upon him less by the small amount of such differences (for he freely admits that, with the ordinary interpretation of the term, they are in some cases *specific*), than by the extent to which they may be referred to certain physical and other influences. That these effect *something* is admitted by all who have written on the subject. That they effect more than any single supporter of the multiplicity of the species of the genus *Homo* has recognised, is certain—at any rate we may seek in vain for the naturalist who has taken in half the complications of the question. Thus—

That the physical characters of our kind are permanent, is argued from such a fact as the mummies of ancient Egypt giving us the same organization that is given by the modern Copts. Why should they not? The country in which they occur is as truly the valley of a certain river, between a certain degree of latitude, now as ever. The only facts on this question that are other than irrelevant are those that show that 2000 years under a *change* of climates go for nothing.

Again—that comparatively light complexions are found in some of the hottest parts of the world, whereas dark ones are found in comparatively cool ones, passes for an argument against the effects of heat on the skin. It only shows that heat is not the *only* cause of an increased secretion of the epidermic colouring matter.

Moisture—light—altitude—what has been done, worthy of the name of science, in the investigation of these influences—even singly? Next to nothing. Let it be granted that a little is known about the acclimatization of new-comers in fresh habitats. The process by which a world is peopled by the gradual diffusion of a given population from the circumference of an ever-increasing circle, has never been imitated, and never will be.

Then there is the question of descent. That two localities, one in Africa, and the other in South America, may so closely resemble each in their physical conditions of heat, light, altitude, moisture, land-and-water relations, as, for the purposes connected with the modification of the human organism, to be considered as identical, is highly probable. What, however, if the human organisms thereof notably differ? Not the inference that physical conditions either act irregularly, or not at all, but that the objects on which

they acted in cases under notice were different. The negro that from (say) Central Asia reaches the Lower Niger is the descendant of ancestors whose organizations were acted upon by the physical influences of a line drawn through south-western Asia and north-eastern Africa, whilst the Indian of the Lower Amazons is the descendant of ancestors whose organizations were acted upon by the physical influences of a line drawn through Siberia, the Arctic Circle, North America, Central America, and the north-western parts of South America.

The phenomenon of transitional and intermediate forms has again been greatly neglected by the advocates of the doctrines under notice.

However, as all this and a great deal more may be worked out with greater care than has hitherto been applied, the doctrine that the species of mankind are numerous is still an open question. Even if what we call the *dynamic* question (the question as to the power of external influences) be settled in favour of the unity of man, there will still be many plausible objections that a little ingenuity may discover. To say nothing about the extent to which the ordinary naturalist views of species may be modified, the value of language as an instrument of classification would be materially altered by any facts which might lead us to believe in the existence of a species of our kind, originally destitute of language, but not destitute of the capability of learning it when heard from others. Again, the value of transitional or intermediate forms as connecting links between extreme types depends greatly upon the character of the facts connected with hybridism and intermixture.

At present, however, we may be satisfied with the doctrines lately laid down, viz.:—

1. That, as a matter of fact, the languages of the earth's surface are referable to one common origin.

2. That, as a matter of logic, this common origin of language is *primâ facie* evidence of a common origin for those who speak it.

For the purposes of exposition, and even for those of investigation, the speculative question as to the unity or non-unity of our species is of far less importance than it seems to be. With ethnology, as with other studies, the bulk of its ordinary results are but slightly affected by the hypotheses that apply to the remoter and more abstruse questions of its obscurer departments. Even if we multiply species to the utmost, the unity classification gives us something. It tells us how language spread, even if it fails to tell us that the populations who spoke that language were specifically the same. Or, if we account for the phenomena of transitional and intermediate forms by the doctrine of hybridism and intermixture, the elements of this hybridism and intermixture are indicated. On the other hand, however, there are grave differences between the classes of the two systems. As long as the species is single our questions are questions of *descent*. Where, however, we have several species, *descent* is out of the question, and the likest groups are those that have the most points of resemblance. Upon the whole, however, the two views give us liker results than we expect *à priori*. This is because the arrangement of *varieties* closely approaches the arrangement of *species*.

To understand this, lay out of the question the islands of the earth's surface, and ask how an ethnologist upholding the unity of our species would people the world. He deduces his population from some point more or less central. His area, being continental, is *continuous*, and he supposes the stream of population by which its several portions were occupied to have been *continuous* also. The spread is that of circles on a still piece of water. Now, if so, *all changes must have been gradual, and all extreme forms must have passed into each other by means of a series of transitional ones.*

It is clear that such forms, when submitted to arrangement and classification, will not come out in any definite and well-marked groups like the groups that constitute what is currently called species. On the contrary, they will run into each other, with equivocal points of contact, and indistinct lines of demarcation; so that discrimination will be difficult, if not impracticable. If practicable, however, it will be effected by having recourse to certain typical forms, around which such as approximate most closely can most accurately and conveniently be grouped. When this is done, the more distant outliers will be distributed over the debatable ground of an equivocal frontier. In short, varieties as opposed to species imply transitional forms, whilst transitional forms preclude definite lines of demarcation.

Yet what is the actual classification of the varieties of mankind, and what is the current nomenclature? To say the least, it is very like that of a collection of species. Blumenbach's *Mongolian*, Blumenbach's *Caucasian*, Blumenbach's *Æthiopian*, are all terms that suit the nomenclature of the naturalist of *genera*. Nevertheless, however much it may give us of broad and trenchant lines of demarcation between varieties which (*ex vi termini*) ought to graduate into each other, it is far from being indefensible.

Man conquers man, and occupant displaces occupant on the earth's surface. By this means forms and varieties which once existed become extinct. The more this extinction takes place, the greater is the obliteration of those transitional and intermediate forms which connect extreme types; and the greater this obliteration, the stronger the lines of demarcation between geographically contiguous families. Hence a variational modification of a group of individuals simulates a difference of species; forms which were once wide apart being brought into juxtaposition by means of the annihilation of the intervening transitions. Hence what we of the nineteenth century—ethnologists, politicians, naturalists, and the like—behold in the way of groups, classes, tribes, families, &c., is beholden to a great extent under the guise of *species;* although they may not be so in reality, and although they might not have been so had we been witnesses to that earlier condition of things when one variety graduated into another and the integrity of the chain of likeness was intact.

A group is sharply defined simply because we know it in its state of definitude; a state of definitude which has been brought about by a displacement and obliteration of transitional forms. An ethnologist, then, may think with advocates of the unity of mankind, and employ the nomenclature of their opponents; in other words, the chief groups into which mankind is distributed are much the same in their relations to each other, whatever may be the opinion as to their absolute value and importance.

The last point to which the attention of the advocate of the plurality of the human species is directed is that of time, it being clear that in any estimation of the effect of physical and other causes upon the human organism, the *duration* of their action is an all-important element. The changes that ten generations fail to effect may be effected by ten times ten. Now, it is too often assumed, that because an investigator supports the origin of mankind from a single pair, he also supports the recent origin of that pair, and by so doing, limits the duration of the forces by which he supposes the existing differences to have been effected to a historical instead of a geological period. The two doctrines, however, by no means necessarily go together.

The consideration of the amount of change that external and other causes *have* effected, leads to the consideration of the changes that are likely to be effected hereafter, to questions as to the acclimatization of colonies in foreign parts, the fitness of the whiter varieties of our kind for the tropics, the fitness of the darker varieties of our kind for the colder portions of the earth's surface, and a long range of similar investigations. Whether, and under what conditions, an

Englishman can become a permanent occupant of such countries as Brazil or India, is a truly ethnological problem, and also one of no mean importance. Akin to this is the valuation of the effects of civilization, and the moral influences that it engenders.

Hence, the chief ethnological problems, generally expressed, are those of (1.) the unity (or non-unity); (2.) the geographical origin (or origins); (3.) the antiquity; and (4.) the futurity of mankind—questions all closely connected with each other, and all mutually illustrative of each other—questions to which the phenomena of classification and the several ethnological methods are subordinate. In the extent to which the whole subject is new, we get the measure of the amount of thought and research requisite for even an approximation to any legitimate ethnological hypothesis upon these large and complicated questions. (R. G. L.)

ETIENNE, St, a large manufacturing town of France, capital of a cognominal arrondissement, in the department of Loire, stands on the Furens, a small affluent of the Loire, 32 miles S.W. of Lyons. Pop. (1851) 53,741. St Etienne is indebted for its rapid rise and present importance chiefly to its being situated in one of the most productive coal fields of France. It likewise derives considerable advantage from the Furens, which furnishes water-power for its machinery. The chief manufactures are fire-arms and silk ribands. About 30,000 or 40,000 stand of arms are made here annually, besides about 30,000 fowling-pieces and 1500 pair of pistols. The ribands are unrivalled for richness of colour and beauty of pattern, and are exported to all parts of the world. The annual value of those manufactured here is estimated at 45,000,000 francs. The other manufactures are bayonets and cutlery, files, nails, anvils, and other iron and steel goods. St Etienne is connected by railways with Lyons and Roanne; whence, by means of the Rhone and Loire, the coal and other products find easy access to all parts of France. The town is irregularly built, but the modern part of it has some wide streets and spacious squares. The houses are built of fine white sandstone, which is soon tarnished and blackened by the smoke of the town. It is the seat of tribunals of primary instance and commerce, and has an ancient cathedral, a town-house, exchange, theatre, a handsome obelisk fountain, museum of local manufactures, national college, public library, council of prud'hommes, deaf-mute institution, and a mining school.

ETIQUETTE (Fr. *étiquette*, a ticket or label affixed to a bag or bundle of papers) originally signified an account of ceremonies. In modern usage etiquette denotes the ceremonial code of polite life, or those forms which are observed towards particular persons, especially in courts, at levees, and on public occasions. The original sense of the word points to the custom of delivering cards containing orders for regulating ceremonies on public occasions.

ETON, a town of Buckinghamshire, on the left bank of the Thames, 21 miles W. of London. It is connected with Windsor, on the opposite bank of the river, by a neat cast-iron bridge, erected in 1824. Eton is chiefly celebrated for its college, founded by Henry VI. in 1440. This establishment consists of a provost, vice-provost, 6 fellows, a head master, under master, 70 king's scholars, 7 lay clerks, and 10 choristers, besides inferior officers and servants. The scholars must be born in England, of lawfully married parents, and be between eight and sixteeen years of age. A number of the head boys are annually nominated to King's College, Cambridge. On their removal to Cambridge they are received on the foundation and maintained out of its endowments, and after three years they succeed to fellowships. There are also two scholarships at Oxford for foundation scholars. Failing an appointment to either university at the age of seventeen, they are superannuated at eighteen or nineteen; and for such there are a few exhibitions in the gift of the college. The scholars are lodged and boarded by the establishment, and by statute their education should be gratis, but a sum of L.6 or L.7 is now charged for their instruction. The degrading system of "fagging," by which the boys of the lower schools are made servants or fags to those of the upper, is still in force here. Besides the scholars on the foundation, Eton College is attended by about 600 scholars who reside in private houses, and are styled *oppidans*. Many of these are sons of persons of rank and fortune. The total expenses of a boy educated as an *oppidan* may average from L.150 to L.200 a-year. The course of instruction is almost wholly classical; and though there are masters for French, German, arithmetic, writing, &c., these branches are unconnected with the general business of the school, and are attended at extra hours. Among the celebrated men who were educated at Eton, may be mentioned Sir Robert Walpole; Harley, Earl of Oxford; Lord Bolingbroke; Earl Camden; the famous Earl of Chatham; the Hon. Robert Boyle; Lord Lyttelton; Gray; Horace Walpole; West; Waller; Fox; Canning; the Marquis of Wellesley; Hallam the historian; and the Duke of Wellington. The singular custom termed the *montem*, which was observed here triennally on Whit Tuesday, has now been abolished. The last celebration of it took place in 1844. It consisted of a procession of the boys in a kind of military order, with flags and music, headed by their "captain," to a small mount called Salt Hill, near the Bath road, where they levied contributions, or "*salt*," from the passers-by and spectators. The sum collected sometimes exceeded L.1000; the surplus, after deducting certain expenses, becoming the property of the "captain" of the school. The college buildings consist of two quadrangles, built partly of freestone but chiefly of brick. The outer quadrangle or school-yard is inclosed by the chapel, schools, dormitories, and masters' chambers, and has in its centre a bronze statue of the royal founder. The buildings inclosing the inner or lesser quadrangle contain the residences of the fellows, the library, hall, and various offices. Between these are the provost's lodge, &c.; appertaining to which is an ancient tower and a gateway in the centre, connecting the two courts. The chapel, on the south side of the outer court, is a fine Gothic edifice, containing some interesting monuments, among which is one to Sir Henry Wotton, who was long provost of the college; and at the west end of the ante-chapel is a fine marble statue of the founder in his royal robes, by Bacon. The library contains a curious and valuable collection of books, a collection of Oriental and Egyptian manuscripts, and some beautifully illuminated missals. The parish church having fallen into decay, the college chapel was used as a substitute; but a handsome church, in the early English style, has recently been erected, at a cost of about L.8000. Pop. of parish (1851) 3666, besides 130 in Eton College.

ETRURIA, an ancient province or country of Italy, bounded on the N. by Liguria, from which it was separated by the river Macra, now Magra; on the side of Cisalpine Gaul, by the lofty ridges of the Apennines; on the E. by Umbria, from which it was separated by the river Tiber; and on the W. by the Tuscan Sea. The country thus situated appears to have been one of the earliest seats of European civilization, and the principal source whence Rome derived her laws, customs, and superstitions.

ETRUSCANS, or TUSCANS, called by the Greeks *Tyrrhenians* or *Tyrsenians*, and by themselves *Rasena*, were the people who inhabited ancient Etruria, and who, at a period when the rest of Europe was immerged in ignorance and barbarism, had attained to a high degree of civil and social refinement.

Etruscans.

The origin of this interesting race, from whom have descended some monuments of the earliest humanity, appears to have puzzled the ancients as much as it has perplexed the moderns; and, notwithstanding all that has been written on the subject, particularly by the Italian antiquaries, it is still beset with difficulties and involved in obscurity. The question chiefly agitated amongst the ancients was whether the Etruscans were Pelasgi from Greece, Lydians from Asia Minor, or an indigenous and aboriginal race in Italy; and the moderns have added more than an equal number to the hypotheses of the ancients. Herodotus represents them as a colony of Lydians, who, having been compelled by famine to emigrate from Asia, arrived, after various wanderings, in Umbria, where they settled and called themselves Tyrrhenians, from Tyrrhenus, son of their king Atys, the conductor of the emigration. This tradition, whencesoever derived, has been almost implicitly followed by the ancient writers; indeed Cicero, Strabo, Velleius Paterculus, Seneca, Pliny, and Plutarch, all agree in repeating the assertion that the Etruscans originally came from Lydia.

But the moderns have not in general evinced the same deference for the authority of Herodotus in this particular, and have advanced a variety of hypotheses, some of them, perhaps, not much more tenable nor better founded than the story told by the father of history. Dempster, who may be said to have laid the foundation of an accurate knowledge of Etruscan history and antiquities, is of opinion that there existed an original nucleus of inhabitants in Etruria, which was successively augmented by the Lydian immigration, and by Pelasgic colonies from Thessaly and Arcadia. Bochart coincides pretty nearly with Dempster, but maintains that there must have existed a direct intercourse between the Etruscans and Phœnicians, as many of the fables, superstitions, customs, and monuments of the former were, according to him, of oriental origin. Winckelman and the Count de Caylus, admitting an ancient communication with the East by means of the Mediterranean, substitute Egypt for Phœnicia; and to the supposed intercourse between Etruria and the land of the Pharaohs the former ascribes the remarkable progress made by the Etruscans in the sciences and liberal arts; whilst the latter is of opinion that this people borrowed every thing from Egypt, and that the origin of science and art in Etruria is coeval with the commencement of their commercial connection with that country. Improving upon these views, some writers have advanced a step further, and maintained that the Etruscans not merely carried on an intercourse with Egypt, but were actually of Egyptian descent, in fact a colony or branch of the great nation established in the Delta and valley of the Nile. This opinion has been adopted by Buonarotti, Gorius, Mazzochi, Maffei, Guarnacci, and Lord Monboddo; but it has been strenuously opposed by a number of the most learned Italian, French, and German archæologists, particularly by Bardetti, Pelloutier, Fréret, Funccius, Adelung, and Heyne, who, though differing from one another in some points, have generally contended for the northern and Celtic origin of the Etruscans. Lanzi, without pretending to investigate the origin of this remarkable people (who, he nevertheless seems to think, were Lydians, augmented at different times by the accession of Pelasgic tribes), endeavours to prove that, whatever may have been their descent, the language, religion, learning, and arts of the Etruscans, were of Greek origin; that the period of their greatest perfection in the arts of design was posterior to the subjugation of Etruria by the Romans, when the intercourse with Greece had rendered them familiar with the beautiful models of that country; and that, even admitting all languages to have been originally derived from the East, and many Greek words to have sprung from Hebrew or Phœnician roots, still there exist in the Etruscan such evident traces of Hellenic descent, particularly in the names of gods and heroes, as to render it almost impossible to derive their origin from any other source. Further, in support of this theory, the learned Italian attempts to show from the inscriptions on the Eugubine tables, that the Etruscan was Æolic Greek, without either the monosyllabic characteristics of the northern dialects, or the prefixes and affixes peculiar to most of the oriental languages. Humboldt, again, supposes this people to have been a connecting link between the Iberians and Latins, or a sort of transplanted offset from the great Celtic stem. But the learned and ingenious Müller adopts an intermediate opinion. Admitting a primitive population of Etruria, as to whose origin he does not venture to decide, he conceives that there are nevertheless grounds for assuming that they became intermingled with Pelasgic colonists from the coast of Lydia, where the latter had for a time settled, and acquired the name which they afterwards rendered notorious by their piracies in the Ægean Sea. It would be hopeless to endeavour to reconcile these conflicting hypotheses, and endless to examine their respective merits in detail.

Of all those, however, who have laboured to resolve this *quæstio vexata* in the archæology of history, Niebuhr has, we think, been, upon the whole, the most successful. The origin of the erroneous opinions as to the extraction of the Etruscans, he traces to two assumptions, which he shows to be equally fallacious: first, that the Pelasgians could only be derived from Greece, a supposition which probably gave rise to the story of the migration from Thessaly; and, secondly, that because the Mæonians were Tyrrhenians, these Tyrrhenians, like those of Lemnos, were of the same stock with the ancient inhabitants of Agylla and Tarquinii, whence arose the story of the Lydian emigration of the ancient Tyrrhenians, as told by Herodotus. But, on the authority of Xanthus, Dionysius proves that the account of Herodotus was not founded upon a Lydian tradition; and, from the complete difference of the two nations in language, usages, and religion, he justly contends that it would deserve no credit, even if there had been a tradition to the effect stated. He asserts that the Etruscans spoke a language which bore no affinity to any other known form of speech; and this assertion would deserve full credit, even if we had only the evidence of Dionysius, inasmuch as Etruscan was then, and for a considerable time afterwards, a living language, in which, as we gather from Lucretius,[1] books were written and read. It is further confirmed by the inscriptions still extant, in which every resource of etymology has failed to detect any analogy between the Etruscan and the Greek language or the kindred branch of the Latin; and these singular monuments, which have thus resisted the utmost efforts of modern scholarship and ingenuity, will to all appearance remain for ever a dead treasure, unless a key shall accidentally be furnished for their interpretation, by the discovery of a bilingual inscription. In opposition to the unanimous evidence of the ancients, who distinguish the Etruscan from the Sabine and Oscan, it has indeed been maintained that all the nations of Italy, remains of whose language occur in inscriptions, spoke only dialects of the

[1] Non Tyrrhena retro volventem carmina frustra
Indicia occultæ Divûm percurrere mentis.

same radical form of speech; but this opinion, which has chiefly prevailed amongst the Italian scholars, is at variance with the results of unbiassed investigation; and it appears to have been completely established that the Etruscan language, being wholly original and peculiar, bore as little affinity to the Sabine and Oscan as to the Latin and Greek, with which fanciful etymologists have vainly sought to connect it.[1]

The Etruscans, during the most prosperous period of their history, inhabited Etruria proper, and the country about the Po, besides distant colonies. The Rætians and other Alpine tribes were also of Etruscan origin; and so were the Lepontians and Camunians, perhaps also the Euganeans, who inhabited Venetia before the founding of Patavium. It has been suggested by Niebuhr that the language spoken by the people of Groeden in the Tyrol, a language which seems to stand alone in its peculiar roots, may have some claims to be considered as a relic of the ancient Etruscan.[2] The Brenner formed the northern boundary of the Rætians, and consequently of the Etruscan race, who in the time of their greatness had probably occupied the mountains as a bulwark against irruptions from the north. Some, however, are of opinion that Rætia was the original home whence the Etruscan people issued, and spread first in Upper Italy, and afterwards across the Apennines; and the harshness of the Etruscan language, which seems still to survive in the Florentine pronunciation, has been adduced as an argument for the Alpine origin of the people.

In the ancient history of the Umbrians it was related that the Etruscans had conquered three hundred towns of their nation. The Umbrians, therefore, must have once occupied the greater part of the countries, including Tuscany, which the Etruscans possessed in the zenith of their power. According to the tradition of the Lydian migration, Pisa, and the whole country to the rocky summits of the Alps, were wrested from the Umbrians by the Tyrrhenians; and Pliny considers the Umbrians as the ancient inhabitants of Etruria who were expelled by the Pelasgians. Without entering into the question whether Cortona was Etruscan or not, still Cære, Graviscæ, Alsium, and Saturnia, were certainly occupied by the Etruscans as conquerors, after expelling the people callèd in Italy Siculians, and in Greece Pelasgians and Tyrrhenians. The Pelasgians were also in possession of Tarquinii before the Etruscans; Populonia was called a colony of the Volaterrans, who had driven the Corsicans from the coast; and Pisa is mentioned by Dionysius amongst the places which the Etruscans had wrested from the Pelasgians. But all statements, however probable or well attested, were at length forced to give way to the story of a Lydian extraction, which of necessity placed the first settlement of the immigrants on the lower sea, and thus involved the whole question in perplexity. What the native annals of the Etruscans related as to their origin we know only negatively; in them the Lydian legend which has created so much embarrassment had no place.[3] According to this view, then, there appear to have been two consecutive conquests: that of the Umbrians by the Pelasgians; and that of the Pelasgians by the Etruscans, who, as it were, absorbed all the others, and ultimately became the dominant people. The principal stock of the nation, however, seems to have been formed out of that great Pelasgian race which at one time extended from the rivers Po and Arno in Italy to the Phyndacus in Asia, but which, even when intermingled by conquest with other tribes, never succeeded in spreading itself over the whole of Northern Italy. The Etruscans, indeed, at no period of their history possessed the whole of Cisalpine Gaul. On the westward their territory extended only to the Ticinus, where dwelt the Ligurians, who were afterwards driven back by the Gauls; and the land to the south of the Po was also

[1] The names of Tuscan and Etruscans were as foreign to this people as that of Tyrrhenians. They called themselves *Rasena*, as already stated; and the other appellations applied to them were evidently arbitrary, accidental, or hypothetical. The ancient Roman terms were *Etruria* for the country, and *Tusci* for the people; that of *Etruscus* did not come into use till after Cato's time, though subsequently it became the more usual in the language of books. But the old name must have continued prevalent in the mouth of the people; for under the later emperors the name of *Tuscia*, which had never before been used in writing, was applied to the country, and in the middle ages passed into *Toscana*, whence *Toscani*. (Niebuhr, *History of Rome*, p. 90, Cambridge, 1828.) Professor Müller thus sums up his researches into the origin of the Etruscans: "It remains that we regard the Tuscan nation as an original and peculiar people of Italy; their language is widely different from the Greek; the names of their gods are not those which we find among the earliest Greeks, whom we call Pelasgi, and which passed from them to the Hellenes; there is much too in the doctrine of their priests entirely foreign to the Greek theology. But it appears to have been the fate of this nation, which never displayed any independent civilization, but only adopted that of the Greeks, to have been indebted for its first impulse towards improvement to a Greek, or at best half Greek tribe. The Tuscans themselves, in their native legends, referred their polity and civilization to the maritime town of Tarquinii and the hero Tarchon, both probably only variations of the Tyrrheni. Here it was that the much-dreaded Pelasgians of Lydia landed and settled, bringing with them the arts which they had acquired at home, or on their way. For the first time, the barbarous land saw men covered with brass array themselves for battle to the sound of the trumpet; here first they heard the loud sound of the Lydo-Phrygian flute accompanying the sacrifice, and perhaps witnessed for the first time the rapid course of the fifty-oared ship. As the legend, in its propagation from mouth to mouth, swells beyond all bounds, the whole glory of the Tuscan name, even that which did not properly belong to the colonists, attached itself to the name of Tarchon, the disciple of Tages, as the author of a new and better era in the history of Etruria. The neighbouring Umbrians and Latins named the nation, which from this time began to increase and diffuse itself, not from the primitive inhabitants, but from these new settlers. For since, in the Eugubine tables, *Tursce* occurs along with *Tuscom* and *Tuscer*, it is impossible not to conclude, that from the root TUR have been formed Tursicus, Turscus, Tuscus; as from the root OP, Opscus and Oscus; so that Τυῤῥηνοί, or Τυρσηνοί, and Tusci, are only the Asiatic and Italian forms of one and the same name." (*Die Etrusker*, vol. i. p. 100.)

[2] Hormayr, *Geschichte von Tyrol*, p. 139. This suggestion is eminently deserving of attention and verification. For as the Etruscan alphabet is known, the determination of a few roots would serve as a fulcrum, by means of which the great lever of tentative interpretation might be applied.

[3] "It is evident," says a late writer, "that the Etruscans themselves believed that they sprung from the Lydians, and that they *inculcated this belief on others*" (Dunlop, *Hist. of Rom. Literature*, vol. ii. p. 7); and he grounds this assertion on a circumstance mentioned by Tacitus (*Annal.* lib. iv. c. 55). Eleven cities of Asia contended, it would appear, for the infamous honour of erecting an altar to Tiberius; and this ridiculous and humiliating question was argued in presence of the tyrant, before that degraded senate whom he had publicly taunted with their abject servility. On this occasion the Sardians, one of the contending parties, insisted on their affinity to the Etruscans; in proof of which they produced a decree of that people, repeating the tale told by Herodotus, and of course attesting the original confraternity of the Sardians with the ancient inhabitants of Etruria. This is the statement of Tacitus. What degree of credit may be due to a document founded upon a vague tradition, flattering to popular vanity, produced in such a cause before such judges, and as to the authenticity of which the historian is silent, our readers will not, perhaps, find it difficult to determine. The only thing surprising is, that in such a competition of servility and adulation, a grave historian should have sought for materials to support an hypothesis, improbable in itself, and at variance with the best authorities on the subject.

either occupied by the latter, or rendered uninhabitable by swamps. When the Gauls made their irruption the Umbrians were still masters of the country now called Romagna; but between the Veneti and the Gauls, Etruscan settlements maintained themselves until the time of the Romans.

This people appear to have had twelve cities to the north of the Apennines, and an equal number to the south of that range. Amongst the former, of which we can give but a very indistinct account, may be classed Verona, which is denominated a Rætian city by Pliny, and Mantua, which is called Tuscan both by him and by Virgil. Hatria, Melpum, and Felsina were also included in the twelve cities north of the Apennines. Hatria, once a place of great commerce, gave its name to the upper sea; Melpum, to the north of the Po, was destroyed by the Boii, Senones, and Insubres, on the same day that Camillus took Veii (in the year of Rome 358); and Bononia, under the name of Felsina, was once the capital of Etruria. The twelve cities south of the Apennines, which were leagued together as the chief places of their respective districts, are nowhere enumerated by name; but Livy incidentally mentions eight of them, namely, Cære, Tarquinii, Populonia, Volaterra, Arretium, Perusia, Clusium, and Rusellæ, as having contributed to forward Scipio's preparations. Cortona was also accounted one of the chief places in Etruria, and both Veii and Vulsinii were probably included in the original number. But whether Capena, or Cossa, or Fæsulæ, completed the twelve, it is now impossible to decide; though there is some reason to believe that Capena, a strong city in a fertile territory, was the twelfth.

The territory belonging to each of these capitals had several provincial towns, some of them dependent colonies, and others inhabited by subjects, the descendants of the old population who had been subdued. But as the Etruscan state was founded on conquest, the government naturally assumed the character of an aristocratical oligarchy. It was not by popular assemblies, nor even by the deliberations of a numerous senate, but by meetings of the chiefs or magnates of the land (*principes Etruriæ*), that the general affairs of the nation were decided on. The assemblies held at the temple of Voltumna were of this exclusive kind, and hence in no degree corresponded with the institutions of really free nations, such as the Latins and the Samnites. These Etrurian chiefs were the persons from whom the Roman youth received instruction in the sacred sciences of divination; they were at once a warlike and sacerdotal caste, the Lucumones whose ancestors had committed to writing the revelations of Tages. But they were patricians, not kings, as has been commonly supposed. Lucumo of Clusium, Lucumo who succoured Romulus, and Lucumo who removed from Tarquinii to Rome, were only powerful men in their respective cities; the Cilnii and Cæcinæ were Lucumones in Etruria, just as the Claudii and Valerii were patricians in Rome, and were not less noble in birth than the latter, though, as Romans, reckoned only amongst the commons. But these ruling houses were exposed to the violent revolutions which everywhere threaten an oligarchy, even in the midst of its own body, when it is not upheld by some powerful protection from without. The chiefs expelled each other by force of arms, or were driven into exile by the combinations of intrigue; and it was in the spirit of these feuds for the refugees to be restored by the dangerous mediation of the common enemy, the Romans. Even so late as the second Punic war, the government of the Etruscan cities remained exclusively vested in the senators, or nobility; the latter were, what Louis XIV. called himself, the state; and, when a ferment began in Etruria, it was entirely suppressed by securing the submission of the senate at Arretium. The people, who had no political existence as such, were out of the question. A free and respectable commonalty was never formed amongst the Etruscans; on the contrary, the species of feudal system, anciently established by conquest, was obstinately maintained and extended; the mass of the population were mere serfs; and hence arose the remarkable weakness of the great Etruscan cities in their contests with Rome, when the victory was to be determined by a numerous, brave, and steady infantry. National impotence ever follows the degradation of the people. What the Etruscans might have been if, some centuries earlier, they had had a country, is evinced by the effect of the Roman franchise conferred upon them at the conclusion of Sylla's war. In this contest the part taken by the chiefs was taken by all; and every free man, however excluded or restricted by the old but now expiring constitutions of his own country, obtained the privileges of Roman citizenship; nor was the boon either undeserved or misapplied.

The regal office, which was not hereditary in a single family, as in Greece, but elective for life, as at Rome, continued at Veii until its fall. At Arretium, however, the king may perhaps have been chosen from amongst the Cilnii, a family of high distinction. The twelve federal cities nominated a common high priest, who presided at the national festivals. In common enterprises the supreme command was generally committed to one of the twelve Lucumones, who received a lictor from each city. Even Porsenna, highly as he is celebrated in the old legends, is in Roman history only king or chief of Clusium; yet he had influence sufficient to set the whole power of the nation in action. In like manner all the twelve cities paid homage to Lucumo Tarquin; and in the earlier times a closer union seems occasionally to have been effected by the power of a supreme chief, as Mezentius or Cœles Vibenna. But such union appears to have been the exception rather than the rule, and to have depended on accident rather than on organization; nor have we been able to discover satisfactory evidence of the existence of a distinct federal constitution, such as some writers have rather gratuitously imagined. Yet loose as was the federal bond in Etruria, it seems to have had the effect of preventing wars between the cities, of which no trace is to be found in history. Such, then, being the nature of their association, it is probable that the islands subject to the Etruscans were not under the dominion of the whole nation, but under that of the adjacent maritime cities; and, accordingly, it seems as if the Cærites stood alone when, leagued with the Carthaginians, they attacked the Phocæans of Alalia, which happened in the year of Rome 220. The principal insular dependency of the Etruscan states was Corsica, which paid them a tribute; but it is not improbable that they had also settlements in the island of Sardinia.

The maritime cities of Etruria having early engaged in navigation, were stigmatised and hated on account of the piracies they committed in the western seas, which, anterior to the founding of the Grecian colonies in Sicily, were thus rendered impassable to peaceful navigators. Niebuhr is, however, inclined to think that this reproach may have applied chiefly to the Pelasgian Tyrrhenians, whom the Etruscans afterwards subdued; and indeed all the corsairs of the lower sea seem to have been considered by the Greeks as Tyrrhenians. But without entering into any details respecting their nautical adventures, whether piratical or other, it may be observed, that navigation naturally implies an interchange of commodities; and a fruitful land, rich in internal treasures, supplied abundant materials for the commercial spirit in Etruria. From a very early period the Etruscan maritime cities appear to have engaged in com-

 merce; and in the time of Aristotle, treaties, by which the rights of trade were respectively determined and secured, subsisted between these cities and Carthage. Amongst the subjects of this commerce may be mentioned the produce of the iron mines of Elba,[1] and of others upon the mainland of Etruria, which yielded a more abundant supply of a purer kind of metal than any in the ancient world. The same island also furnished copper for their coinage, and for those works in brass or bronze in which they so greatly excelled. Müller supposes them to have also traded in amber, which substance, he thinks, they received by an inland route, extending from the shores of the Adriatic to those of the Baltic; but as his chief reason for this supposition appears to be, that, in Pliny's time, amber was conveyed by the same route into Italy, and as no safe conclusion can be drawn respecting the extent of early communications, from those which are found established at a later period, when circumstances had wholly changed, the conjecture in question must, we suspect, be dismissed as untenable. On the subject of Etruscan commerce, however, the information which has reached us is too scanty and imperfect to enable us to deduce any distinct conclusions, either as to the extent to which it was carried on, or the particular channels in which it flowed.

The works constructed by the Etruscans still astonish us even in their ruins, and could scarcely have been executed in small states without taskmasters and bondsmen. The everlasting monuments of Egypt are the products of the direst tyranny acting remorselessly upon the most abject slavery. But the scarcely less durable works of the Etruscans differ from those in the valley of the Nile, in having all of them been directed towards some great object of public utility. Labour was not uselessly or wantonly expended in the erection of pyramids, obelisks, and temples, to gratify the inordinate vanity of despots, or to extend the empire of superstition; if the people suffered in the hard service imposed on them, it was not for vain or idle purposes; they were employed by their rulers on whatever seemed best calculated to promote the defence or augment the wealth of the nation at large. The walls of their cities, constructed of huge blocks of polygonal stones, still subsist in imperishable solidity, where pains have not been taken to demolish them; the theatre at Fiesole, and a colossal building near it, are on a scale of equal grandeur; and other monuments might be mentioned which have been constructed in the same Cyclopean style. The rich valley of the Arno, anciently a lake and a swamp, was drained by means of a cut through Mount Gonfalina, which blocked up the valley, but which, by means of this operation, was made to afford a passage for the stream towards Pisa; the arms, too, by which the Po discharges itself, were also excavated or directed by the Etruscans; and its Delta was likewise the fruit of their labours. Another useful art practised by this people consisted in letting off, by means of tunnels, lakes which had been formed in the craters of extinct volcanoes. In the territory of Perugia there are traces of many such lakes, which have been completely dried up, by means of the tunnels, which, though now unknown and never cleared out, still drain off the water as before.

The renown which belongs to a nation that excelled in the arts has become as it were the inheritance of the Etruscans. But from the peculiar constitution of government and society in ancient Etruria, it has been conjectured, not without appearance of reason, that the works in bronze and clay, and the bas-reliefs, attributed to them, were the produce, not of the dominant race, but of their subject bondsmen or serfs; and that in reality the Etruscans, properly so called, were as little given to the arts as the Romans by whom in their turn they were subdued. The striking difference observable between Tarquinii and Arretium in their works of art, seems to correspond with the different origin of the earlier inhabitants of northern and southern Etruria. Volaterra was naturally led, by the stone quarries in its neighbourhood, to engage in the works for which it became celebrated. The two former cities, however, wrought only or chiefly in clay. Arretium made red vases, with elegant figures in relief, in a style altogether peculiar. Those of Tarquinii were painted, and both in colour and design resemble some discovered near Corinth, of which Dodwell has given engravings. Painted vases are found only in the district of Tarquinii, and where they occur those of Arretium are never met with; besides, they differ from the Campanian in all those peculiarities for which the Greek works of the same kind are distinguished. The resemblance which is thus found to exist between the vases of Tarquinii and of Corinth irresistibly reminds us of the story of Demaratus, who is said to have been accompanied by the potters Euchir and Eugrammus; a circumstance evidently designed to express that Tarquinii derived from Greece her skill in handling clay, and the elegant drawing with which her vases were adorned. The earliest Etruscan statues were of clay; but the statues belonging to the first ages of Rome were almost uniformly of bronze, and the master-pieces which shed lustre on Etruscan art are all of the same material. That this art received its refinement from the Greeks cannot, we think, be reasonably questioned. Works of primitive antiquity attest its original rudeness; and to the Greeks alone, improving on Egyptian models by a close study of the finer forms and proportions of nature, belonged that skill which throws life and beauty into the delineation of the human figure. Hence the subjects of many of the most beautiful Etruscan works of art are obviously taken from the Greek mythology, which, in Etruria, was found as well adapted to the purposes of the artist as in the land to which it was native. But the Etruscans, when their taste had once been formed, treated their own conceptions in the spirit of their masters; and, though no doubt inferior in grace and delicacy of execution, they acquired a correctness in drawing which may almost be stated as a national characteristic. In the she-wolf of the Capitol we have an example of the perfection to which Etruscan art had attained about the middle of the fifth century of Rome; nor are the finest gems probably of a much more recent date. See Plates CCLIII., CCLIV., and CCLV.

As a national heroic story was wanting to Etruscan art, it sought for subjects in the Greek mythology; and the legends of Thebes and of Ilium must have been familiar to the people. The Greek poems were read in Etruria, and Greek legends, transfused into Etruscan, lived in the speech of the nation, or in compositions in the native tongue. Indeed the works of art are not unfrequently inscribed with the names of the Greek heroes, adapted to the forms of the Etruscan language, of which it is matter of regret that so little is yet known. Varro mentions Tuscan tragedies by one Volnius, who, it appears, lived not long before, and probably intended these as an experimental attempt to introduce a national drama. But be this as it may, the Grecian construction of the theatre at Fæsulæ is evidence that Greek dramas, either originals or translations, were performed there, as well as at Tusculum and Bovillæ in Latium; nor can it be doubted that this

[1] Insula inexhaustis chalybum generosa metallis. (*Æn.* x. 174.)

theatre is much earlier than the time of Sylla, since in size and magnificence it far surpasses the scale of a Roman military colony, which, besides, cannot be supposed to have had any taste for the exhibitions peculiar to such a place. The amphitheatre was the only place to which such colonists would have repaired for amusement. It is proper to add, however, that in Etruscan inscriptions we do not find any thing bearing the slightest resemblance to Greek rhythms, which could scarcely have been concealed even in an unintelligible language; and that the place whence the Fescennine musical dialogue received its name was a Faliscan, not an Etruscan town.

The music of the Romans was derived from Etruria, whence also they obtained their scenic or histrionic singers. This is the only branch of art in which the ancients attributed to the Etruscans the honour of invention; but here the invention related merely to the instrument; for we do not read of any mood or measure ascribed to the Etruscans. This instrument was the flute, which the Romans regarded as native to Etruria, though modern antiquaries pretend that it is to be considered as of Lydian origin, and even as a proof of the Lydian immigration mentioned by Herodotus. The celebrity which the Etruscans obtained in music, as well as in other accomplishments, was, no doubt, in part owing to their having been the neighbours of a rude and uncultivated people like the Romans, who naturally admired whatever was new or strange, and who, until they became acquainted with the Greeks, derived all that was ornamental in their system of public and private life from Etruria.

The literature of the Etruscans presents the singular phenomenon of an alphabet almost perfectly deciphered, with a language completely unintelligible. A combination so strange has led more than one writer to maintain that the language is Pelasgic or Æolic Greek, and to appeal in proof of this to the alphabet; but, unfortunately, there is a total want of connection between the premises and the conclusion; and the result of all the investigations yet instituted has been to disprove this notion. The Etruscan characters were formed like the Greek, from that one amongst the various Asiatic alphabets whence all the modes of writing in use throughout Europe appear to have been derived. That Etruria received them directly from the Phœnician would not certainly be proved by the direction of the writing from right to left; but when to this we add the omission of the short vowels, the practice of noting double consonants by a single letter, as in all the Aramaic systems of writing, and the want of the vowel O, which are peculiarities purely Punic, the presumption in favour of Phœnician origin is considerably increased. From this last circumstance, however, nothing can be decisively determined as to the pronunciation, inasmuch as the Semitic languages are not defective in the vowel, which is wanting to the Etruscan. The Phœnicians also distinguished numbers by letters; but not so the Etruscans. What we denominate the Roman numerals are of Etruscan origin, and occur frequently on their monuments, being probably the abbreviated remnants of a hieroglyphical art of writing in use before the alphabetical, and, like the Aztecan numerals, representing objects connected with particular numbers. Niebuhr thinks them indigenous to the west. But however this may be, the literal form which these numerals have now assumed cannot mislead any one as to their hieroglyphical origin. With respect to the Etruscan language, which remained harsh in sound and uncouth in its forms, all the labour which has hitherto been bestowed in attempting to interpret it, though valuable for its collateral results, has proved wholly fruitless in reference to its direct object. Lanzi, abandoning the oriental and northern etymology, endeavoured to explain the Etruscan from the Pelasgic; and for many years after the appearance of his Essay, his explanations were acquiesced in, and even made the basis of various etymological hypotheses. But when at length credulity gave place to inquiry and examination, it was perceived that his modes of proceeding were much too arbitrary; that he had produced no evidence of the existence of the words and forms which he had assumed to be Greek, in order to identify them with the Etruscan; and that other monuments, discovered since his time, could not in any way be explained by his system. In short, his interpretation was purely tentative and conjectural, without even accidental felicities of supposition; and hence, of all the Etruscan words, of which pretended explanations have been given, only two (AVIL RIL, *vixit annos*, or rather perhaps *ætatis annos*) seem to have been really interpreted. Professor Müller's observations on this subject are well deserving of attention, especially in reference to the expectations which appear to be entertained of the enlargement of our historical knowledge by the comparison of languages.

"We might give much ampler satisfaction," says he, "if, after Lanzi's method, we sought in the monuments of the Etruscan language for single sounds resembling the Greek and Latin, and, persuaded that similar sounds must have a similar meaning, endeavoured to explain all that could not be brought to agree, by an arbitrary prothesis, epenthesis, paragoge, and similar cheap expedients. Without blaming the learned Italian, in whose time the most eminent literati had very confused ideas of the formation of language, we may maintain that his leading principle (that analogy is the character only of cultivated languages, and that the ruder any language is, the greater liberty might be taken in the use of it) is entirely false. This may justify us for having paid so little regard to etymologies, which, as they are arbitrary in themselves, suppose an arbitrary character in the language to which they are applied. If we use only genuine monuments, and require a certain evidence for every explanation of a root or a grammatical form, our apparent knowledge of the Etruscan language shrinks almost to nothing....... It is not probable that the application of the still existing remains of the languages of the north and north-west of Europe should have those beneficial results for our knowledge of Etruscan which some appear to anticipate. The Germans and Celts are originally divided in a very marked manner, by their locality, from the nations of the Mediterranean; they only gradually approach these and come into collision with them; and even though the languages of both nations may belong to that great family which from time immemorial has diffused itself throughout Europe and Asia, yet they have distinct peculiarities, which we have no reason to believe are found in those of Italy. One fundamental and indelible characteristic of the Celtic languages seems to be, that they mark grammatical forms by aspiration and other changes of the initial consonants; a thing not practised in any other European language, but found in all the branches of the Celtic, as the Welsh, Cornish, Gaelic, Irish, and *Bas Brêton*. This mutability of the consonants is a circumstance which must be perceptible even in a small number of written remains, and which could not well have escaped us had the Etruscan been Celtic. The Iberian family, once widely diffused on the shores of the Mediterranean, may have dwelt in close vicinity to the Etruscans; but the remains of its language in the Basque are completely different from the rest of Europe; and its grammar shows so little affinity with what we know of the Etruscan, as to afford very slight support to the opinion of the affinity of the two nations. What may have been the relation of the Tuscan to the extinct Ligurian, or to the language of those Alpine

tribes whose names alone are preserved in history, is a question respecting which we have not even a glimmering of knowledge."[1]

Any attempt indeed to interpret the Etruscan, without the aid of bilingual inscriptions, such as those on the Rosetta stone and obelisk of Philæ, which afforded a key to the Egyptian phonetic hieroglyphics, will be pure loss of labour. The discovery of such monuments, however, is, in regard to time and manner, an incalculable event; but still it is within the range of probable calculation; and the age which has witnessed the interpretation of Egyptian hieroglyphics by means of such aids should not hastily despair of anything. If a translation were discovered, not in Latin or Greek, but in Oscan or even Umbrian, the latter have so much affinity to the Latin, that much might be learned from such a version for the explanation of the Etruscan. By the successive labours of Lassen, Grotefend, Botta, Hincks, Layard, and, above all, of Colonel Rawlinson, we have at length obtained a clew to the Assyrian *arrow-headed character;* and the ingenuity which has unravelled the mysteries of Egyptian hieroglyphics, it is not unreasonable to expect will yet penetrate the cloud that has so long veiled the meaning of those ancient records of Etruria.

Of the early history of Etruria we can only collect a few detached facts of little importance, which are to be gleaned from Livy, and from short notices in the Greek historians and poets; and must ever deplore the loss of the works of Aristotle and Theophrastus on the civil institutions of the Tyrrheni, as well as regret that the history of the Emperor Claudius has disappeared. We find this people engaged in a contest with Tarquinius Priscus (about 610 B.C.), but obliged to acknowledge at least a nominal dependence on the power of Rome. They joined the Carthaginians in an attack on the Phocæans, who having left Asia Minor (about 547 B.C.) to escape the persecutions of Cyrus the elder, had settled in Corsica, and threatened to dispute with them the supremacy of the western seas. For the next two centuries they appear to have enjoyed tranquillity; until, roused to exertion by the ever encroaching spirit of the Romans, they determined to make a united effort to check the power of their dangerous neighbours. The hostile forces met (309 B.C.) near Lake Vadimon, which is still to be seen on the east of Etruria, near the Tiber, below the modern village of Bassano; and the result was, as usual, favourable to the cause of Roman supremacy. The Tuscans were completely defeated; and from this moment were compelled to co-operate in extending and strengthening the power of the conqueror. They now became incorporated with the Roman people, and can no longer be considered as a separate nation.

For a detailed account of this people, see Micali *L'Italia avanti il dominio dei Romani*, Milan, 1825, with *Antiqui Monumenti per sevire all' Opera intitolato* L'ITALIA, &c., Frienze, 1821; *L'Italie avant la Domination des Romains*, with historical notes and illustrations by M. Raoul-Rochette, Paris, 1824, in 4 tomes; Niebuhr's *Roman History*, English trans., Cambridge, 1828, in 2 vols.; Müller, *Die Etrusker, vier bucher*, Breslau, 1828; Inghirami, *Monumenti Etruschi o di Etrusco nome*, 1821–1825, in 6 vols. 4to; Heyné, *Etrusca Antiqua*, Nov. Soc. Götting. 1766; and Gori, *Museum Etruscum*. For the ancient language of Etruria, see Dempster, *De Ætruria Regali*, Florence, 1723, in 2 vols. fol.; Lanzi, *Saggio di Lingua Etrusca, e di altre Antiche d'Italia*, 1789, in 3 vols. 8vo; and Müller, *Die Etrusker*, above referred to. (J. B—E.)

The excavations recently made within the limits of the ancient Etruria, and the researches of various Italian and foreign antiquaries, have, within the last few years, thrown additional light on the sites of Etrurian cities, and illustrated the arts and manners of that singular people. The English reader will find a lively account of some of these discoveries in the pages of Mrs Hamilton Gray, and a more ample and well-digested detail in *The Cities and Cemeteries of Etruria* by George Dennis, published in 2 vols. in 1848. In this work we find the following enumeration of the sites of Etrurian cities, most of them established on very fair data.

Veii.........near	Isola Farnese.
Fidenæ.........	Castel Giubleo.
Falerii, *Vet. et Nov*.........	Civita Castellana.
Feronia.........	St Oreste.
Capena.........	Chiesa di S. Martino.
Norchia, or Orcle?.........6 miles from	Vetralla.
Castellum Axia.........	Castel d'Asso.
Blera.........	Bieda.
Tarquinii.........near	Corneto.
Vulci.........on the Fiora near	Ponte della Badia.
Tuscania.........	Toscanella.
Volscinii.........	Bolsena.
Salpinum.........near	Ovieto?
Cære or Agylla.........	Cervetri.
Pyrgi (its port).........	Santa Severa.
Pisæ.........	Pisa.
Rusellæ.........	Rosella.
Cosa.........	Assedonia.
Populonia or Pupluna.........	Populonia.
Vetulonia, discovered in 1842.........	Magliano.
Telamon (its port).	
Saturnia.........	Saturnia.
Clusium.........	Chiusi.
Arretium.........	Arezzo.
Perusia.........	Perugia.
Cortona.........	Cortona.
Fæsulæ.........	Fiesole.

Second-rate Towns.

Sustrum.........	Sutri.
Nepale.........	Nepi.
Surrena or Sorena.........	Viterbo?
Horta.........	Orte.
Graviscæ.........on right bank of the	Marta, on the coast.
Statonia?.........near	Tarquinii, at Castro.
Alsium.........	Palo.
Fregellæ.........	Torre de Maccarese.

Unascertained Etruscan remains

At Corchiano.	At Cetana.
Galere.	Sarteano.
Vignanelle.	Chianciano.
Orbitello.	Montepulciano.

ETSCH, a river of Italy. See ADIGE.

ETTLINGEN, a town of Baden, capital of a cognominal bailiwick in the circle of Middle Rhine, five miles S. of Carlsruhe. It is situated on the Alb, and has cotton-spinning, gunpowder, and paper mills. Pop. 4500.

ETTMÜLLER, MICHAEL, an eminent physician, born at Leipzig, May 26, 1644. After having studied languages, mathematics, and philosophy, at his native town, he went to Wittenberg, whence he again returned to Leipzig, and obtained a medical diploma in 1666. After travelling in Italy, France, and England, he retired to Leyden, where he had intended to spend some time in study, but was suddenly recalled to Leipzig in 1668, where he received the degree of doctor immediately after his arrival. The Academy of the Curious in Nature admitted him as one of its members in 1670, and the Faculty of Medicine in 1676. About the same time the university of Leipzig confided to him the chair of botany, and appointed him extraordinary professor of surgery; the duties of which he discharged with distinction. But he did not long enjoy his preferment; for he was suddenly cut off, 9th March 1683, in consequence of a hectic fever, occasioned, as some say, by a chemical experiment. Although Ettmüller only wrote short dissertations and mere *opuscula*, he nevertheless enjoyed an immense reputation. He had the art of interest-

[1] *Die Etrusker*, vol. i., p. 64, *et seq.*

ing and fixing the attention by a ready elocution, and by arguments sometimes much more specious than solid. The following is a list of his works :—

De Singularibus, a thesis defended by Ettmüller in 1663; *Medicina Hippocratis Chimica*, Leipzig, 1670, in 4to; *Vis Opii diaphoretica*, Leipzig, 1679, in 4to; *Chimia Rationalis ac Experimentalis curiosa*, Leyden, 1684, in 4to; *Medicus Theoria et Praxi generali instructus*, Frankfort and Leipzig, 1685, in 4to; *Opera Omnia theoretica ac practica*, Lyons, 1685, in 4to; *Opera Omnia; nempe Institutiones Medicinæ cum Notis, etc.*, Frankfort, 1676, 2 vols. fol.; *Operum Omnium Medico-physicorum editio novissima*, Lyons, 1690, 2 vols. fol.; *Opera Omnia in Compendium redacta*, London, 1701, and Amsterdam, 1702, in 8vo. The best edition is that of his son, entitled *Opera Medica theoretica-practica per filium Michaelem Ernestum, etc.* Frankfort, 1708, 3 vols. fol. There is no complete translation of the works of Ettmüller, but there are numerous German, English, and French translations of the different treatises.

Michel Ernest Ettmüller, son of the preceding, born at Leipzig in 1673, was also a physician of some eminence. Besides collecting and editing the works of his father, he wrote a number of theses and memoirs. He died Sept. 25, 1732.

ETTRICK, a river, parish, and forest of Selkirkshire. See SELKIRK.

ETTY, WILLIAM, R.A., one of the most eminent of British painters, was, like Stothard and Flaxman, a native of York, where he was born 7th March 1787. His father had been in early life a miller, but had finally established himself in the city of York as a baker of spice-bread. His mother was in many respects a remarkable woman, and from this parent Etty, like many other men of genius, inherited the qualities by which he became distinguished in after life. The painter was the seventh in a family of ten, five of whom died young. With so many children to provide for out of comparatively slender means, it was impossible for the elder Ettys either to educate their family themselves or to send them to the public schools of the city. After some scanty instruction of the most elementary kind, the future painter, at the age of eleven and a half, left the paternal roof, and was bound apprentice in the printing-office of the "Hull Packet." Amid many trials and discouragements he completed his term of seven years' servitude, and having in that period come to know his own powers, he removed at the close of it to London. The kindness of an elder brother and a wealthy uncle stood him in good stead during his long and noble struggle against the trials and difficulties that beset the career of nearly every person who adopts the profession of art for its own sake. After a year and a half of preliminary study, he was enrolled in 1807 as student of the Academy, whose schools were at that time conducted in Somerset House. Among his fellow scholars at this period of his career were some of those who in after years rose to eminence in their art, such as Wilkie, Haydon, Collins, Constable, and others who still survive. This year is also memorable in Etty's life as that in which he enjoyed the privilege of the private instructions of Sir Thomas Lawrence, who was now at the very acme of his fame. Etty himself always regarded this privilege as one of incalculable value, and till his latest day regarded Lawrence as one of the chief ornaments of British art. For some years after he quitted Sir Thomas's studio, even as late as 1816, the influence of his preceptor was traceable in the mannerism of his works; but his later pictures prove that he had completely outlived it. Though he had by this time made great progress in his art, his career was still one of almost continual failure, hardly cheered by even a passing ray of success. It was not till 1811 that the sun began to shine upon him. In that year, after repeated rejections, he had the satisfaction of seeing his first picture on the walls of the Academy's exhibition-room. For the next five years he persevered with quiet and constant energy in overcoming the disadvantages of his early training with yearly growing success, and was even beginning to establish something like a name, when in 1816 he resolved to improve his knowledge of art by a journey to Italy. After an absence of three months, however, he was compelled to return home without having penetrated farther south than Florence. Struggles and vexations still continued to harass him, but he bore up against them with a patient endurance and force of will which ultimately enabled him to rise superior to them all. He had resided at home nearly six years since his unsuccessful journey into Italy, when he resolved to make arrangements by which he should be enabled to spend at least eighteen months in that native country of the pictorial art. Accordingly in 1822 he set out on his tour, taking Paris on his way, and astonishing his fellow-students at the Louvre by the rapidity and fidelity with which he copied from the old masters in that gallery. On arriving at Rome he immediately resumed his studies of the old masters, and elicited many expressions of wonder from his Italian fellow-artists for the same qualities as had gained the admiration of the French. Though Etty was duly impressed by the grand chefs d'œuvres of Raphael and Michael Angelo at Rome, yet he was not sorry to exchange that city for Venice, which he always regarded as the true home of art in Italy. His own style held much more of the Venetian than of any other Italian school, and he admired his prototypes with a zeal and exclusiveness that sometimes bordered on extravagance. Early in 1824 he returned home to find that honours long unjustly withheld were awaiting him. In that year he was made an associate of the Royal Academy, and three years later he was promoted to the full dignity of an academician. In the interval between these dates he had produced the "Combat," and the "Judith," both of which ultimately came into the possession of the Scottish Academy, which body, to their credit be it told, were the first to discern and publicly appreciate the genius of Etty, and the value of his contributions to art. Etty's career was from this time one of slow but uninterrupted success. His works were not now as formerly allowed to remain upon his hands unsold; and though the prices which they fetched were almost incredibly small in comparison with the value now attached to them, yet they satisfied the artist's requirements, and even tempted him to persevere in the dangerous career of high art. In 1830 Etty again crossed the channel with a view to another art-tour through the Continent; but he was overtaken in Paris by the insurrection of the Three Days, and was so much shocked by the sights he was compelled to witness in that time, that he returned home with all convenient speed. During the next ten years of his life the zeal and unabated assiduity of his studies was not at all diminished, and he continued with marvellous regularity his various routine-duties in connection with the Academy, though his health was far from robust, and his circumstances were now such as to put it in his power to dispense with the multifarious drudgery which the fulfilment of these duties demanded. The course of his studies was only interrupted by occasional visits to his native city, and to Scotland, where he was welcomed with the utmost enthusiasm, and *fêted* with the most gratifying heartiness by his brother-artists at Edinburgh. On the occasion of one of these visits he gave the finishing touches to the trio of Judiths, which form not the least interesting or valuable feature in the collection of the Scottish Academy. In 1840, and again in 1841, Etty undertook a pilgrimage to the Low Countries to seek out and examine for himself the masterpieces of Rubens which exist in many of the churches and public galleries there. Two years later he once more visited France with a view to collecting materials for what he called "his last epic," his famous picture of "Joan of Arc." This subject, which would have tasked to the full even his great powers in the prime and vigour of manhood, proved almost too serious an undertaking for him in his old age. It exhibits, at least, amid great excellences, undeniable proofs of decay on the part of the painter; yet it brought a higher price than any of his earlier and more

Etty.

perfect works, viz. L.2500. In 1848, after completing this work, he retired to York, having realized a comfortable independence. Even his advanced years and increasing infirmities were as yet unable wholly to quench his artistic enthusiasm; for when his health allowed, he worked as assiduously as in his younger days. One wish alone remained for him now to gratify; he desired to see a "gathering" of his pictures. With much difficulty and exertion he was enabled to assemble the great majority of them from various parts of the British islands; and so numerous were they, that the walls of the large hall he engaged in London for their exhibition were nearly covered. This took place in the summer of 1849: on the 13th of November of that same year Etty died. On the occasion of his funeral, which was a public one, and attended by the corporation of York, the shops in the city were shut, the bells of the various churches were tolled, and other marks of respect paid to the memory of the deceased artist.

Etty has delineated himself in his autobiography (published in the Art-Journal), and in his letters and diaries recently (1855) given to the world in Mr Gilchrist's "Life" of this celebrated artist. The reproach often alleged against artists and men of science, that as men they are most frequently quite uninteresting, cannot with truth be asserted against Etty. In many points of view his is not only an interesting but a highly instructive career. Born of humble parents, without any advantages of early training, and in the face of difficulties before which any man might honourably have given way, he yet achieved for himself, by the innate force of genius, a conspicuous place in that walk of art which he selected for his own. It was not by a brilliant precocity, or the factitious success which sometimes accompanies the skilful mannerist or the daring innovator in art, but by a means resembling the slow certainty with which most of the great discoveries in physical science have been made in accordance with the inductive method, that he attained this result. Year after year he struggled on, often heart-sick and weary of the contest, yet with the inflexible resolution of reaching the point proposed, and in the attempt removing, so far as in him lay, the reproaches to which English art had too often been exposed from its successful cultivators on the Continent. The Italians, especially the Venetians, were the first to recognise very decidedly Etty's merits, more especially as a colourist. While copying the great masters in the Venetian galleries, he was often complimented with such expressions as "è un Ercole," "è un Tiziano," &c., and that not by casual acquaintances anxious to ingratiate themselves with him, but by fellow-artists as able and willing to detect blemishes as to acknowledge beauties. Similar and equally decided compliments were showered down upon him by the French who had opportunities of seeing him at work in the Louvre. The world at large now fully appreciates the works of this painter; and though it be too much to say that Etty equalled Titian as a colourist, yet it may perhaps be allowed to claim for him the name of the English Rubens, and all the respect and honour due to such a title. In private life Etty was in many respects an admirable type of the English character. The lessons which he learned in early life from his mother continued to guide and influence him to the end; and though his religionism appears to have held more of sentiment than of study and conviction, yet it stood him in equally good stead in so far as it led him safely through the temptations with which the life of the artist is frequently beset. In the expressions of simple piety, manlike faith in the wisdom and goodness of an over-ruling Providence, and child-like submissiveness to its dispensations, the letters of Etty abound almost as much as those of Cromwell. For trivial backslidings, such as many men fall into without a thought, Etty implores forgiveness as fervently as if he had committed some heinous sin. The same principle seems to have actuated him in his dealings with his fellow-men. From the feeling of jealousy so common among artists, and from which he suffered so much himself, he was completely free. There is no more striking instance than his on record of generosity towards distressed fellow-artists, and of liberal encouragement of art, both by direct pecuniary aid and by the devotion of much valuable time to the service of the Academy. Towards his native city his heart always yearned with the most earnest longing. The course of modern improvements threatened from time to time the destruction of some of the interesting antiquities of the city. On these occasions the painter was ever ready both with tongue and pen to protest against the impending vandalism, and with such success that nearly everything that now remains to differentiate York from other provincial towns in England is due to his exertions. His grief for the Minster, which on two occasions was nearly destroyed by fire, was as poignant and lasting as is often testified by parents for the loss of a favourite child. His homeliness and domestic notions of comfort are also very English in character. Even in the course of his repeated journeys to the Continent, he used to carry with him a complicated tea-apparatus, which often excited the curiosity and suspicion of the custom-house officers in the various countries which he entered. (For a detailed account of the life, character, and habits of Etty, see the careful and interesting "Life" recently published by Alexander Gilchrist, Esq., of the Inner Temple, London.)

Etymology ‖ Eubœa.

ETYMOLOGY (ἔτυμος, *true*, and λόγος, *discourse*), that branch of philology which treats of the origin and derivation of words, with a view to ascertain their radical or primary signification.

EU, a town of France, department of Seine-Inferieure, arrondissement of Dieppe, and 17 miles N.N.E. of the town of that name. It is situated on the small river Bresle, about two miles from its mouth, in the English Channel, and contains about 4000 inhabitants. Eu was a place of some importance in the middle ages, but it was burned by Louis XI. in 1475 to prevent its falling into the hands of the English, and has never attained its former condition. It is chiefly remarkable for its *château*, built by the Duke of Guise in 1578 on the site of a castle destroyed with the rest of the town in 1475. This château was greatly enlarged and richly decorated by Louis-Philippe, to whom it came by succession, and here he received the Queen of England in 1843. It is surrounded by an extensive park and gardens. The parish church is a fine Gothic edifice, under which is a crypt containing numerous monuments of the Artois family.

EUBŒA (now Egripo or Negropont), the largest island in the Ægean Sea, is separated from the coasts of Attica, Bœotia, Locris, and Thessaly, by the Eubœan Sea, which, at its narrowest part, between Chalcis and the Bœotian shore, is called the Euripus. The length of the island, whose general outline is long and narrow, is about 90 miles; its breadth varies considerably—at the broadest part it measures about 30 miles, at the narrowest not more than four. It is traversed throughout its entire length by a mountain range, some of the peaks of which attain a great elevation. On the eastern coast Dirphys or Dirphe, now Mount Delphi, rises 7300 feet above the sea. At the southern extremity the highest mountain is Oche, now called St Elias, rising to the height of 4750 feet. On the western side, the highest peaks are Mounts Kandhili and Telethrius, the former 4200 and the latter 3100 feet above the sea. At the foot of Mount Telethrius are the celebrated hot springs, known as the Thermæ. Opposite the entrance of the Maliac Gulf is the promontory of Cenæum, near which is Mount Lithadha nearly 2900 feet high. At the N.E. extremity of the island is the promontory of Artemisium, celebrated for the great naval victory gained by the Greeks

over the Persians, B.C. 480. The continuous plains in the island are few in number and comparatively small in extent. The largest of these is that of Lelantum, between Eretria and Chalcis; next that of Histiæa, at the northern extremity of the island, opposite the coast of Thessaly. The south-western portion of the island was called Geræstus, the south-eastern Caphareus.

Eubœa was believed to have originally formed part of the mainland, and to have been separated from it by an earthquake. Its northern extremity is separated from the Thessalian coast by a strait which at one point is not more than a mile and a half in width. From the promontory of Cenæum southwards for about fifteen miles the depth of the channel is so great that half a mile from the shore no bottom has been found with 220 fathoms of line. The water, however, gradually shoals from this point to Chalcis. At this town the strait, assuming the name of Euripus, contracts to a breadth of not more than 120 feet; and a bridge has been thrown across it at this point, connecting the island with the Bœotian coast. The rivers of Eubœa are so few in number, and so scanty in volume, that the scarcity of water is often severely felt. On the eastern side are the Budorus, and the Lelantus flowing through the plain of the same name. On the north coast was the Callas. Two other streams, the Cereus and the Neleus, are mentioned, about which nothing is known save that sheep dipped in the former became white and those in the latter black. The level ground of Eubœa, which is of no great extent, was fertile in corn; while the mountains afforded excellent pasture for sheep and cattle. These pastures belonged to the state, and were let out to such as could afford to pay the necessary rent. In the mountains were several valuable mines of iron and copper; and the marble quarries of Carystus at the south of the island were among the most important of Greece.

Eubœa was originally known under other names, such as Macris, Helliopia, Oche, and Abantis. By Homer the inhabitants of the island are called from this latter name Abantes, though the island itself is mentioned under its name of Eubœa by the same poet. In historical times Eubœa was inhabited chiefly by Ionic Greeks, and of these the Athenians were the most prominent. As the island never at any time formed a separate state, it is impossible to give a general history of it as a whole. The history of the leading cities will be found under their respective heads. See CHALCIS, ERETRIA, HISTIÆA, &c. For the modern history of Eubœa, see NEGROPONT.

EUBULIDES, a native of Miletus, was a distinguished philosopher of the Megaric school. The principal events in his personal history are quite unknown. Indirect evidence shows that he was a younger contemporary of Aristotle, whose philosophy he attacked with great bitterness, and that he numbered Demosthenes among his pupils for a while. He is not known to have written any independent work, and his name has been preserved chiefly on account of some celebrated though false and captious syllogisms of which he was the reputed author.

EUBULUS, a distinguished comic poet of the middle comedy, was a native of Athens, where he flourished about B.C. 370–80. He is said to have written no fewer than 104 plays, of fifty of which the titles have been preserved by Suidas. The fragments of Eubulus that survive have been edited by Meineke, and serve to show, if nothing else, at least that his diction was remarkably pure and tasteful.

EUCHARIST (εὐχαριστία, *thanksgiving;* from εὖ, *well,* and χάρις, *favour*), the sacrament of the Lord's Supper; the solemn act of commemorating the death of our Redeemer, in the use of bread and wine as emblems of his flesh and blood. See SUPPER OF THE LORD.

EUCHOLOGIUM (εὐχή, *prayer;* λόγος, *a discourse*), literally *a discourse on prayer;* applied to the Greek ritual, in which are prescribed the order of ceremonies, sacraments, and ordinances. Gore has given an edition of the Greek euchologium in Greek and Latin, with notes.

EUCLASE, formerly called *prismatic emerald,* a very rare mineral of a pale green colour. See MINERALOGY.

EUCLID (EUCLIDES) OF ALEXANDRIA, author of the most ancient elements of geometry which have come down to us, and hence justly regarded as one of the fathers of science. He has been sometimes confounded with Euclid of Megara. The place of his birth is unknown. But Proclus Diadochus, one of his commentators, informs us that he opened a school of mathematics in Alexandria in the reign of Ptolemy the son of Lagus; and Pappus extols his kindness and affection for those who laboured to advance the study of geometry. This being all that is known of the life and character of Euclid, it only remains therefore to speak of his works, some of which have been lost. Amongst those which we possess, however, the most remarkable is that which is simply entitled *Elements,* as if to indicate that it contained the entire body of principles upon which the pure mathematics then rested. This work now consists of fifteen books; but the last two are attributed to Hypsicles, a mathematician of Alexandria who flourished at a later period. Euclid, however, neither was nor could be the inventor of all that is contained in his work; for geometers more ancient than he, including Hippocrates of Chio, had written Elements; but, on the other hand, there can be little doubt that he added to the pre-existing stock of elementary truths, improved the demonstrations in which his predecessors had failed, and composed a whole which, by more severe forms of reasoning, and a more exact concatenation of propositions, superseded all works of the same description which had been previously written, and became the basis of instruction in the mathematics. These *Elements* were first commented on by Theon, and by Proclus; but whatever success such commentaries may have had in the school of Alexandria, they remained wholly unknown to the occidentals of the middle ages, who derived all their knowledge of geometry, such as it was, from the works of Boethius, and from a production entitled *De Principiis Geometriæ,* ascribed to St Augustin.[1] It was only in the twelfth and thireenth centuries that Athelard in England and Campano in Italy laboured to decipher and translate Euclid from the Arabic versions, including the commentary of the Persian geometer Nazir-Eddin, which was held in great estimation among the Saracens; for although there is reason to believe that Boethius had made a complete Latin translation of Euclid, it has not come down to our times; and, in fact, it was not till long after the revival of letters, and when versions had been multiplied by means of the press, that a part of the *Elements* of Euclid was introduced into the course of instruction in the schools. In order to form an idea of the entire work, however, it may be considered as composed of four parts. The first of these parts comprehends the first six books, and may be divided into three sections, viz., the demonstration of the properties of plane figures treated in an absolute manner, as in books first, second, third, and fourth; the theory of the proportions of quantities in general, which is the object of the fifth; and the application of this theory to plane figures, as in book sixth. The second part contains the seventh, eighth, and ninth books, which are denominated *arithmetical,* because they treat of the general properties of numbers. The third part consists only of the tenth book, in which the author considers in detail incommensurable quantities, and which he terminates by proving that the diagonal of a square and its side cannot have a common measure; a doctrine, we may add, which is

[1] Montucla, *Histoire des Mathématiques,* tom. i., pp. 212 and 492.

much more ancient than Euclid, since Plato, towards the close of his seventh book of *Laws*, pronounces those who have no idea of such incommensurability as sunk in almost brutish ignorance. The fourth part, which is composed of the last five books, treats of planes and solids. But of all this great body of geometrical doctrine, the only portions which have been considered as adapted to the purposes of instruction are the first six books, together with the eleventh and the twelfth; the propositions which they contain having formed the basis of all the elements of geometry which, under whatever form, have from time to time been given to the world. The fifth book, however, has often been omitted in such publications, because the notation of our arithmetic, and still more that of our algebra, have greatly simplified the theory of proportions; and, for the same reason, the other arithmetical books, which it is now difficult to read, are justly considered as more curious than useful. But, in borrowing their materials from the work of Euclid, modern authors have frequently altered the arrangement; and on this subject there have arisen two contradictory opinions, which have been debated with very great warmth, yet still remain as irreconcilable as ever. The concatenation established by Euclid, and even the forms which he has employed in demonstrating his propositions, are regarded by some as almost the last term of perfection in works of this kind; whilst others, again, have considered these as mere essays, which, however excellent in themselves, leave room for the introduction of a more natural order and more simple demonstrations. Ramus, who declared war on the dialectics of Aristotle, accuses Euclid of omissions and redundancies, and expresses his conviction that it was with reference to these imperfections that Ptolemy inquired if there were not a more easy method than that usually employed for learning geometry; an inquiry which, as is well known, elicited from Euclid the reply, that in the mathematics there was no road for kings. Antony Arnauld, and the author of the Port-Royal Logic, have also blamed the order followed by the Greek geometer, and disputed some of his definitions;[1] but if Arnauld, either from not being very profound in the mathematics, or by reason of the great difficulty of the subject, failed, as Ramus and so many others had done, in the changes which he attempted to introduce into the *Elements*, his reasons for making the attempt still remain in all their force. For, whatever may be said to the contrary, it is certain that they are deficient in that order which, causing the propositions, as far as possible, to arise out of one another, exhibits in full evidence the analogies which connect them, assists the memory, and prepares the mind for the investigation of truth. But whether, in the actual state of the science, it be practicable to reconcile this order with the rigour of demonstration, or to obviate objections the force of which, abstractedly considered, cannot be disputed, is a question which it would far exceed the limits of this notice to discuss.[2] If it be resolved affirmatively, which appears to us possible, then no reason would exist for giving an absolute preference to the *Elements* of Euclid. As a precious relic of antiquity, and as one of those works of science which time has thrown least in arrear of actual knowledge, the *Elements* would doubtless continue to be classed in the first rank of mathematical productions; but their too arbitrary arrangement, and the style in which they are written, sometimes too prolix, and at other times too concise, would no longer constitute the essential character of the geometric or synthetic method, in opposition to the analysis of the moderns. The true difference of these two methods of treating the science of quantities consists in this, that the one is founded on the immediate consideration of the properties of figures, whilst the other employs arbitrary signs, combined by the operations of calculation. The first is geometry itself, not that of Euclid more than of any other; the second is an application of algebra, which ought not to be confounded with analysis, inasmuch as synthesis may be effected with algebraic signs as well as with the figures of geometry. The latter, however, which may also be treated analytically, presents operations equivalent to the resolution of certain equations. Of this some propositions contained in the book of *Data* are remarkable examples; propositions which, by a natural and certain path, lead to the solution of problems otherwise undiscoverable. The book of *Data* was particularly relished by Newton, who, persuaded that a proposition scarcely deserved to see the light unless it could be demonstrated without the assistance of calculation, conceived that a more profound study of this treatise would have enabled him to dispense with the aid of such an instrument. But it may well be doubted, to say nothing more, whether his successors, by pursuing a similar path, would have ever attained those great and striking results which they have derived from the new methods of calculation.

Besides the *Elements* and the *Data*, which are the most important works of Euclid, Pappus and Proclus mention the following: *Introductio Harmonica, Sectio Canonis*, relating to music; *Phænomena*, containing an exposition of the appearances produced by the motion attributed to the celestial sphere, a work subjoined to the book *De Sphæra Mobili* of Autolycus; *Optica, Catoptrica*, concerning direct vision and mirrors; *Liber de Divisionibus*, treating of the divisions of polygons; and the lost works, entitled *Porismatum libri, Locorum ad superficiem libri, Fallaciarum liber*, and *Conicorum libri*. At the end of the works of Euclid is a short fragment entitled *De Levi et Ponderoso*, the author of which is unknown; it is, however, of almost no value. The editions of the works of this geometer are so numerous that we cannot undertake to indicate all of them, and must therefore confine ourselves to the principal ones. Of the complete works there are, 1. *Euclidis Opera, Græce, cum Theonis expositione, cura Grynæi*, Bâle, 1530, in fol.; 2. *Euclidis quæ supersunt omnia, ex recensione Davidis Gregorii, Græce et Latine*, Oxford, 1703, in fol.; 3. *Les Œuvres d'Euclide, en Grec, en Latin, et en Français, d'après un Manuscrit très ancien, qui était resté inconnu jusqu' à nos jours* par Peyrard, Paris, 1814, in 8vo. The manuscript here referred to was one of several sent from Rome by Monge, and supposed to date from the end of the ninth century: in it the *Data* are placed immediately after the thirteenth book, and thus separate from the rest of the work the fourteenth and fifteenth books, which are ascribed to Hypsicles. In 1533, Hervage published at Bâle, in folio, a complete edition of the *Elements*, in the Greek text, with the exposition of Theon, and the Commentaries of Proclus on the first book. The following are the principal Latin translations: *Præclarissimum Opus Elementorum Euclidis perspicacissimi in artem Geometriæ*, the first publication of the *Elements* by means of printing, Venice, 1482; *Euclidis Elementorum libri XV. una cum scholiis antiquis, a Frederico Commandino Urbinate in Latinum conversi, Commentariis quibusdam illustrati*, Pesaro, 1572, in fol.; *Euclidis Elementorum libri XV. demonstrationibus accuratisque scholiis illustrati, auctore Christophoro Clavio*, 1574, in 8vo; *Euclidis Elementorum libri XV. breviter demonstrati, opera I. Barrow*, London, 1678, in 8vo; *Elementorum Euclidis libri XV. ad Græci contextûs fidem recensiti et ad usum tyronum accommodati, edente Baermann*, Leipzig, 1769, in 8vo; *Euclide Megarense philosopho, solo introduttore delle scientie mathematiche diligentemente reassettato per Nicolo Tartaleo Brisciano*. This last, however, is rather a paraphrase than a translation. There are many other editions which only contain part of the *Elements*: but for further details see Murhard, *Bibliotheca Mathematica* (tom. ii. pp. 1–48), and other similar works. We have not thought it necessary to notice the more recent editions of the *Elements*, which are in the hands of every body. See also GENERAL INDEX. (J. B—E.)

EUCLIDES, a disciple of Socrates, who, after the death of that philosopher, retired to Megara, where he founded a school of philosophy. We know very little of his principles except in so far as they stand related to the sceptical school of a later period. His followers were generally distinguished by their dialectic subtlety; and as a consequent of this they

[1] See *Nouveaux Elémens de la Géométrie*, and the Fourth Part of the *Logique Port-Royal*.

[2] Lacroix, *Essais sur l'Enseignement en général, et sur celui des Mathématiques en particulier*, Paris, 1805.

found themselves speedily reduced to universal doubt. The philosophy of Euclid was expounded in six dialogues, which are now lost.

EUDEMUS, a disciple and contemporary of Aristotle, was a native of Rhodes. His importance in the history of philosophy may be judged from the fact, that after his master he and Theophrastus were regarded as the only worthy exponents of that great thinker's doctrines. He was himself the author of some works on the Categories, on Physics, and on Analytics, which have all perished, but his fame rests chiefly on his editorial comments upon Aristotle. So closely has he followed out his master's system, that some of Aristotle's works have, in modern times, been attributed bodily to him. Certain it is, that to him we are indebted for a valuable portion of that philosopher's work on Physics, left imperfect and incomplete by his death; and it is also not unlikely that he bore a principal share in the editing and arrangement of his Ethics. No details of Eudemus' personal history have come down to us.

EUDIOMETER (εὐδία *pure air*, and μέτρον *a measure*), the name of an instrument or of any apparatus subservient to the chemical analysis of the atmospheric air. The first instrument for this purpose was introduced under the idea that the salubrity of the atmosphere depended upon its relative quantity of oxygen; but it is now known that the amount is not subject to any appreciable fluctuation, but that atmospheric air, when it has perfect freedom of motion and mixture, contains in all situations 20 volumes of oxygen in 100. The practice of eudiometry has been extended to other gaseous mixtures, chiefly for the purpose of determining the amount of oxygen they contain. This method of analysis is described under CHEMISTRY, vol. vi., p. 464.

EUDOCIA, the celebrated wife of Theodosius II., was the daughter of the Athenian sophist Leontius, or Leon, and was called Athenais prior to her conversion to Christianity. By her father she was carefully instructed in literature and the sciences; and so high an estimate did the philosopher make of her beauty and merit, that he divided his whole patrimony between his two sons. Athenais, however, resented the injustice, and carried her plea to Constantinople before the emperor. Here she gained access to Pulcheria, the sister of Theodosius, and by her she was secretly destined to be his wife. Before her elevation to the throne, she renounced Paganism and was baptized. It was not, however, till the birth of a daughter that she received the title of Augusta (A.D. 423). Her brothers she not only forgave, but raised to the dignity of consuls and præfects. About A.D. 438, Eudocia made an ostentatious pilgrimage to the Holy Land, distributing alms and donations for pious purposes, with a munificence which exceeded that of the great Helena, and returned to Constantinople with the precious relics of St Stephen, St Peter, and the Virgin. Her peace, however, was soon after disturbed by the jealousy of her husband, who happened to receive from Paulinus, his master of the offices, a beautiful apple which he had presented to his wife. The execution of the favourite, and the retreat of Eudocia to the solitude of Jerusalem, did not appease the anger of the emperor, who despatched a messenger for the purpose of putting to death two ecclesiastics who had gained her confidence. The assassination of his envoy provoked the emperor still further, and Eudocia was stripped of her royal honours, and degraded in the eyes of the nation. Among the monks of Jerusalem she became infected with the Eutychian heresy; but the misfortunes of her daughter Eudoxia led her to obtain a reconciliation with Pulcheria, and through her influence and that of her brothers she was afterwards restored to the communion of the church. She died at Jerusalem about A.D. 460, and was buried in the church of St Stephen. With her latest breath she protested that she had never transgressed the bounds of innocence and friendship. The talents of Eudocia were especially in her later years devoted to the service of the church. She composed a paraphrase on the Octateuch in heroic verse, a paraphrase of Daniel and Zechariah, and a poem on the martyrdom of Cyprian and Justina. To these are added a poem on her husband's victory over the Persians, and, according to Zonaras, a cento of the verses of Homer applied to the life and miracles of Christ.

EUDOCIA was also the name of several other Roman empresses; the most notable was Eudocia Augusta of Macrembolis, wife of the Emperor Constantine XI., and after his death of Romanus IV. She had sworn to her first husband on his deathbed not to marry again, and had even imprisoned and exiled Romanus, who was suspected of aspiring to the throne. Perceiving, however, that she was not able unaided to avert the invasions which threatened the eastern frontier of her empire, she revoked her oath, married Romanus, and with his assistance dispelled the impending danger. She did not live very happily with her new husband, who was warlike and self-willed, and was ultimately compelled to vacate the throne in favour of her son Michael. She retired to a convent, where she died at an advanced age.

EUDOXIANS, a sect of heretics, also called Acacians, who held a middle position between the Arians and Semi-Arians. See ACACIANS.

EUDOXUS, a celebrated physical philosopher of antiquity, was a native of Cnidus, and flourished about the middle of the fourth century B.C. It is chiefly in his quality of astronomer that his name has descended to our times. What particular service he rendered to that science beyond introducing the Egyptian sphere into Greece, and correcting the length of the year, cannot now be ascertained. Of his personal history, it is only known that he studied at Athens under Plato, but being dismissed by that philosopher, passed over into Egypt, where he remained for sixteen months: that he then went to Cyzicum and the Propontis, where he taught physics, and ultimately migrated with a band of pupils to Athens, where he died in the fifty-third year of his age.

EUERGETES (*i. e.*, *well-doer*, or *benefactor*), a title of honour frequently conferred by the Greeks on those who had done the state some service. This title was also assumed by several of the Græco-Egyptian kings and others. The most notable of these kings to whom this name was applied was Ptolemy III., eldest son and successor of Ptolemy II. Philadelphus. Receiviug his hereditary dominions from his father in a high state of prosperity and civilization, he greatly enlarged their original boundaries by his conquests in Asia. He first invaded Syria, to punish the cruelty and misgovernment of his brother-in-law, Antiochus II., king of that country. Many Syrian cities voluntarily opened their gates to him, and he seems to have penetrated as far as Antioch without meeting any opposition. Here, instead of crossing the Taurus, he turned his arms eastwards, reduced Mesopotamia, Babylonia, and Susiana, and received the submission of the countries lying between these points and the confines of Asia. In the course of this expedition he recovered all the statues of the Egyptian gods which had been carried off by Cambyses, and by restoring these to their original temples, earned the gratitude of his subjects, who conferred upon him that title by which he is known in history as the benefactor of his people. On his return home he seems to have directed his chief attention to the internal administration of his kingdom, and to have turned his arms against the Ethiopian tribes on its southern frontier. He was no less careful than his father had been to protect and encourage letters. He added so much to the Alexandrian Library, that he is sometimes, though erroneously, reputed to have been its founder. After raising his kingdom to a pitch of power and prosperity such as it had never attained before, he died, B.C. 222, not with-

Eugene. out a suspicion of having been poisoned by his son, whose after career afforded only too good grounds for the rumour.

EUGANEAN HILLS, a range of hills of Venetian Lombardy, in the western part of the delegation of Padua. They extend for about 10 miles from N.W. to S.E., between the Bacchiglione, the Monselice canal, and the Bisato. The chain presents few points of great elevation, the highest being Mount Venda, 1920 feet above the level of the sea, which is well wooded and cultivated, and has some thermal springs, resorted to for bathing.

In ancient times a people known as the Euganei occupied, at one time, all the country lying between the Alps and the head of the Adriatic, part of which territory they were afterwards compelled by the Veneti to evacuate. They are believed to have been originally an independent and very powerful people; and even in the time of Pliny they continued to subsist, and are known to have enjoyed the Latin franchise. No light has yet been thrown upon the origin of the Euganei. Their name has given rise to the idea that they sprang from a Greek source, but it is more probable that they were an offshoot from some of the early Gallic invasions of Italy.

EUGENE, FRANÇOIS, commonly called PRINCE EUGENE OF SAVOY, one of the greatest generals of his time (since he preceded Frederic II., and Turenne had fallen before he became known as a commander), was born at Paris on the 18th October 1663. His father, Eugene Maurice, count of Soissons, was grandson of the Duke of Savoy, Charles Emmanuel I.; and his mother, Olympia Mancini, was niece of Cardinal Mazarin; but the latter having been implicated in the affair of the poisonings, was forced to take refuge in Brussels in order to avoid prosecution. Originally destined for the church, Eugene evinced but little taste for theology, and occupied himself much more in reading the lives of great warriors, and the narratives of their exploits, than in studying the works of the fathers. Nevertheless he was of a feeble constitution; and as he wore a dark cloak, he was known at court by the name of the Little Abbé. Louis XIV. refused him a company in a regiment of cavalry, because, according to some, he thought the young prince unfit for the profession of arms, whilst, according to others, this refusal was owing to the disgrace of his mother, and the hatred which Louvois bore to her. But however this may be, Eugene was so stung by the refusal, that, from the moment of his repulse, he conceived for the king and his minister that long and fatal resentment which at length caused so many evils to France.[1] Having quitted France in disgust, he proceeded to Vienna, where the Emperor Leopold, who was allied to his family, received him kindly, and granted him permission, along with several other Frenchmen of distinction, to serve against the Turks under the banners of Austria. His first campaign was that of 1683, during which his courage appeared so conspicuous that the emperor, by way of recompense, gave him a regiment of dragoons. After several other campaigns made with equal distinction, at the head of the same regiment, he became major-general; and it was in this capacity that he served at the siege of Belgrade in 1688. At the instigation of Louvois, a decree of banishment from France was now issued against all Frenchmen who should continue to serve in foreign armies. "I shall return into France in spite of him," said Eugene, when the news were communicated to him; and he continued to pursue with the same ardour the career on which he had entered in so brilliant a manner. In his case genius was stimulated by resentment. Eugene.

Leopold, considering him as not less fitted for diplomacy than for war, sent Eugene as his envoy or negotiator to the Duke of Savoy, in order, if possible, to detach that prince from his connection with France. Nor did the result disappoint the expectations of the emperor. Overcome by the pressing solicitations of his young cousin, the duke allowed himself to be drawn so precipitately into the coalition against France, that, without waiting for the succours which the court of Vienna had promised him, he imprudently gave battle to Catinat at Staffarde, and was defeated, notwithstanding the great courage which Prince Eugene there displayed at the head of a corps of cavalry. But the auxiliary force sent by Austria having at length arrived, Eugene assumed the command, and, after obtaining some advantages, which placed the Duke of Savoy in a condition to defend himself, he returned to Vienna, where he decided the emperor to send fresh reinforcements. The imperial forces were thus put in a condition to resume the offensive; and Prince Eugene having arrived to command them in the spring of 1691, he caused the siege of Coni to be raised, took possession of Carmagnole, and gloriously terminated the struggle in which he had found himself engaged with Catinat. It was, in fact, as much by his successes, as by the ascendency which his superior mind exercised over the Duke of Savoy, that he managed to retain that prince in the coalition, from which he was oftener than once on the eve of breaking off, in order to throw himself again into the arms of France. Desirous to attach him still more to its interests, however, the court of Vienna conferred upon him the title of generalissimo of its forces; and it was in this capacity that he penetrated into Dauphiné at the head of ten thousand men, having Prince Eugene as his lieutenant. The combined army took possession of Embrun and Gap; laid the whole country in ashes, by way of reprisals for the burning of the Palatinate; and was preparing to carry its ravages even into Provence and Languedoc, when the generalissimo having been seized with the small-pox, this accident saved the French provinces from further devastation. Prince Eugene led the army back into Piedmont, and it was there that he received the brevet of field-marshal. After a third campaign of little importance, the Duke of Savoy having again joined the French, and thus turned the balance against the Austrians, Prince Eugene returned to Vienna, where he was appointed to the command of the army of Hungary.

It was about this time that Louis XIV. secretly offered him the baton of a marshal of France, with the government of Champagne, which his father had held, and also a pension of two thousand pistoles. But Eugene rejected these offers with indignation, and proceeded to combat the Turks commanded by the grand signior Kara-Mustapha in person. After some able marches and skilful manœuvres, he surprised the enemy at Zenta, on the Teisse,

[1] "Quelques historiens, bons ou mauvais, se donneront peut-être la peine d'entrer dans les détails de ma jeunesse, dont je ne me souviens presque plus. Ils parleront sûrement de ma mère, un peu intriguante à la vérité, chassée de la cour, exilée de Paris, et soupçonnée, je crois, de sorcellerie, par des gens qui n'étaient pas de grands sorciers. Ils diront comment je suis né en France, et comment j'en suis sorti, la rage dans le cœur contre Louis XIV., qui m'a refusé une compagnie de cavalerie, parce que, disait-il, j'avais une complexion trop faible; et une abbaye, parce qu'il prétendait (sur je ne sais quels mauvais propos sur mon compte, ou fausses anecdotes de galerie de Versailles) que j'étais plus fait pour le plaisir que pour l'église. Il n'y a de Huguenot chassé par la révocation de l'édit de Nantes, qui lui ait conservé plus de haine. Aussi, quand Louvois, apprenant mon départ, dit, *Tant mieux, il ne rentra plus dans ce pays-ci*, je jurai bien de n'y rentrer que les armes à la main; j'ai tenu ma parole." (*Vie du Prince Eugene*, now known to be the production of the Prince de Ligne.)

in a camp retrenched *en tête-de-pont;* and, after an attack as vigorous as it was daring, he killed twenty thousand of them, drove ten thousand into the river, made prisoners of the remainder, and took the whole of their artillery and equipages. Never had a more complete and decisive victory been obtained by the imperial arms. But this splendid achievement, at the same time that it fixed upon Prince Eugene the eyes of all Europe, inflamed to the last degree the jealousy of his rivals, or rather enemies, of whom he had many at court, some of them not less powerful than vindictive. By means of their intrigues, these persons had caused an order to be sent the prince, commanding him to suspend all attack; and this order had reached him an instant before the battle commenced, but without changing his determination to assault the enemy's position; the opportunity for striking a blow was propitious, and he boldly resolved to profit by it. This act of disobedience to the orders of the sovereign was doubtless a fault, and he who dared to commit it would have been ruined without resource had he not triumphed in a manner the most complete and decisive. But was not such a fault gloriously effaced by a victory as useful as it was brilliant? So at least thought all the world, excepting the enemies of Prince Eugene, who succeeded in persuading the emperor that nothing could excuse his disobedience; and, accordingly, when the victorious general appeared before his master, under the impression no doubt that he was to be greeted with acknowledgments and felicitations, he met with a cold and severe reception. Nor did the folly and ingratitude of his enemies stop here. Next day he was placed under arrest, and ordered to deliver up his sword; and he was about to be brought before a council of war, when the inhabitants of Vienna interposed, loudly remonstrating against the injustice of such treatment. The emperor also, whether from fear or repentance, relented, and restored his command to Prince Eugene, who, however, accepted it only on the condition that he should have *carte blanche.* It is alleged that when the envoy of the emperor came to demand his sword, he replied, "There it is, still reeking with the blood of the enemy; I consent not to resume it except for the advantage of his majesty's service." But it is now proved that this pretended reply is spurious; for, as the Prince de Ligne well observes, "one half of the phrase would have been a gasconade, and the other a meanness," neither of which comported with the simple and manly character of this great warrior. Prince Eugene then returned to Hungary; and, after a campaign distinguished by no remarkable event, a treaty of peace was at length concluded with the Turks at Carlowitz, on the 26th January 1699.

Having returned to Vienna, the prince applied himself to the study of the arts, and particularly of history, which had always great attractions for him. But he was not permitted long to enjoy the leisure which he seemed so desirous to improve. The war of the succession, which soon broke out, opened to him a new field of glory; and at the commencement of the year 1701, he was sent into Italy once more to oppose his old antagonist Catinat. But all the prudence of the old general failed to secure him against the bold and incessantly-renewed enterprises of his young and indefatigable rival. The latter effected, in presence of the French army, the passage of the Adige, and forced it, after sustaining several checks, to retire behind the Oglio, where a series of reverses equally unexpected and severe led to the disgrace and retirement of Catinat. The Duke of Villeroi succeeded to the command of which Catinat had been deprived, and the prince had soon reason to felicitate himself on a change which, from its first announcement, transported him with joy. The presumptuous Villeroi having ventured to attack him at Chiari, in an inexpugnable position, Eugene repulsed all his efforts without difficulty, and inflicted a severe loss on the assailants. And this first check was only the forerunner of more signal reverses; for, in a short time, Villeroi was forced to abandon the whole of the Mantuan territory, and to take refuge in Cremona, where he seems to have considered himself as secure in the midst of his staff. But, by one of the most audacious enterprises which has ever been attempted in war, this place was surprised, and, had it not been for untoward accidents, would unquestionably have been carried. By means of a stratagem, Prince Eugene penetrated into the city during the night, at the head of a numerous body; and it was only owing to circumstances which could not possibly be foreseen or provided against, and particularly to the courage and vigilance of some French officers, that he found himself at length compelled to retire, carrying along with him Villeroi as a prisoner. But this last circumstance, so far from being an advantage to the Imperialists, proved the reverse; the Duke of Vendôme replaced the captive general, and his ability soon changed the aspect of affairs. From the first moment Prince Eugene appreciated the talents of his new adversary; and, besides, being aware of the superiority of the French army, with which the king of Spain in person had just effected a junction at the head of numerous reinforcements, he confined himself to a war of observation, without important results, though fertile in most useful lessons to students of military science. This campaign was terminated by the battle of Luzara, fought on the 1st of August 1702, in which each party claimed the victory. It was one of the most sanguinary ever delivered by Prince Eugene, whose fortune it was to command in so many battles; he there lost the flower of his army, and also his best officers, including the brave Commerci, his intimate friend and most faithful companion in arms.

Both armies having entered into winter quarters, Eugene returned to Vienna, where he was appointed president of the council of war. He then set out for Hungary in order to combat the insurgents in that country; but his means proving insufficient, he effected nothing of importance. The revolt was, however, put down by the success which General Heister obtained in another quarter. Prince Eugene accordingly proceeded to Bavaria, where, in 1704, he made his first campaign along with Marlborough. Similarity of tastes, views, and talents soon established between these two great men a friendship which is rarely to be found amongst military chiefs, and which contributed more than all other causes put together to the success which the allies obtained. The first and perhaps the most important of these successes was that of Hochsett or Blenheim, gained on the 13th of August 1704, where the English and imperial troops triumphed over one of the finest armies which France had as yet sent into Germany.

But since Prince Eugene had quitted Italy, Vendôme, who commanded the French army in that country, had obtained various successes. The Duke of Savoy, who had once more deserted France and joined Austria, had suffered severe losses; and the emperor having decided to send him assistance, Piedmont thus became the principal theatre of active hostilities. Having received orders to proceed thither without delay, Eugene quitted Marlborough with the most lively regret, though at the same time experiencing a secret satisfaction at the prospect of measuring himself with a rival in all respects worthy of him. Vendôme at first opposed great obstacles to the plan which the prince had formed for carrying succours into Piedmont; but after a variety of marches and countermarches, in which both commanders displayed signal ability, the two armies met at Cassano, where a murder-

ous engagement ensued, and Prince Eugene received two severe wounds, which forced him to quit the field. This accident decided the fate of the battle, and for the time suspended the prince's march towards Piedmont. But although prevented from effecting a junction with the Duke of Savoy, his operations failed not to prove advantageous to that prince, since the Duke de la Feuillade, then besieging Turin, was obliged to raise the siege and march to the assistance of Vendôme, who, notwithstanding his victory at Cassano, felt apprehensive of some new and daring enterprise on the part of his antagonist. Vendôme, however, was recalled, and La Feuillade was incapable of long arresting the progress of such a commander as Eugene. After once more passing several rivers in presence of the French army, and executing one of the most skilful and daring marches he had ever performed, the latter appeared before the entrenched camp at Turin, which place the French were now besieging with an army eighty thousand strong. Prince Eugene had only thirty thousand men; but his antagonist was the Duke of Orleans, who, though full of zeal and courage, wanted sufficient experience to enable him to contend with a man justly regarded as one of the greatest warriors of his time. Besides, by a secret order of Louis XIV., who had, in fact, transferred the command to Marsin, the young prince was restricted to the execution of an ill-conceived plan, which neutralized the advantage of superior numbers, and put it in the power of the enemy to select his point of attack. With equal courage and address, Eugene profited by the misunderstanding which the exhibition of such an order could not fail to produce between the French generals; and having on the 7th September 1706 attacked the French army in its entrenchments, he gained a complete victory, which decided the fate of Italy. This brilliant achievement, the result of the most masterly combinations, and, in several respects, the prototype of the campaign of Marengo in 1800, affords one of the most remarkable examples of the difficulty of defending extensive lines even against an inferior army, massed upon one or two points. As soon as the Duke of Orleans observed the imperial army approaching, he wished to march out of the lines with the whole French army, and to deliver battle in the open field, where he could have availed himself of his great numerical superiority (eighty thousand to thirty); but he was restrained by Marsin, who, by this absurd interposition, sealed the fate of the French army, and lost Italy. In the heat of the battle, which almost immediately ensued, Eugene received a wound, and was thrown from his horse into a ditch. His fall produced a belief that he was killed, and his soldiers began to lose courage; but he soon returned to the attack, and when the soldiers saw him appear in the midst of them covered with slime and blood, issuing his orders, and watching over every thing with the most admirable sang-froid, their enthusiasm was raised to the highest pitch; and from that moment the issue of the battle was certain. As a recompense for so important services, the prince received the government of the Milanese, of which he took possession with great pomp on the 16th April 1707.

The attempt which he made against Toulon, in the course of the same year, failed completely, because the invasion of the kingdom of Naples retarded the march of the troops which were to have been employed in it, and this delay afforded Marshal de Tessé time to make good dispositions. Obliged to renounce his project, therefore, the prince repaired to Vienna, where he was received with great enthusiasm both by the people and the court. "I am very well satisfied with you," said the emperor, "excepting on one point only, which is, that you expose yourself too much." This monarch immediately dispatched Eugene to Holland, and to the different courts of Germany, in order to forward the necessary preparations for the campaign of the following year, 1708.

Early in the spring of 1708 the prince proceeded to Flanders, in order to assume the command of the forces which his diplomatic ability had been mainly instrumental in assembling. This campaign was opened by the victory of Oudenarde, to which the perfect union of Marlborough and Eugene on the one hand, and the misunderstanding between Vendôme and the Duke of Burgundy on the other, seem to have equally contributed. This prince immediately abandoned the Low Countries, and remaining in observation, made no attempt whatever to raise the siege of Lille, where Boufflers distinguished himself by a glorious defence. To the valour of the latter Eugene paid the most marked and flattering homage, at the same time loading him with all those expressions of esteem and regard with which it was then usual, in such cases, to attemper the horrors of war. Boufflers was invited by his enemies to prepare the articles of capitulation himself, and Prince Eugene wrote to him, "I subscribe to every thing beforehand, well persuaded that you will not insert any thing unworthy of yourself or of me." After this important conquest, Eugene and Marlborough proceeded to the Hague, where they were received in the most flattering manner by the public, by the states-general, and, above all, by their esteemed friend the pensionary Heinsius. Negotiations were then opened for peace, but as the conditions proposed by the allies were considered by Louis XIV. as alike degrading to himself and to France, both parties made preparations for continuing the war.

The campaign of 1709 was opened in Flanders by two hostile armies, each a hundred and fifty thousand strong. That of the French was commanded by Villars, a man of considerable talents, but of little experience, and who feared to compromise himself in opposition to such great captains as Marlborough and Eugene. He accordingly remained upon the defensive, and suffered them to take Tournay without opposition; but being desirous of succouring Mons, he was followed by the allies, who attacked him at Malplaquet on the 9th of September, in a formidable position, where he had had time to entrench himself. The attack was made with equal vigour and ability; but owing to the strength of the French position, and the tenacity with which it was maintained, the victory was purchased at the cost of twenty-five thousand men killed on the field of battle, and the Dutch infantry was almost annihilated. The battle of Malplaquet was to it what the battle of Rocroi had been to the infantry of Spain; and it never afterwards recovered from the effects of that sanguinary day. Although the allies remained masters of the field of battle, this barren advantage had been so dearly bought, that they found themselves soon afterwards out of all condition to undertake any thing. Their army accordingly went into winter-quarters, and Prince Eugene returned to Vienna, whence the emperor almost immediately dispatched him to Berlin. From the king of Prussia the prince obtained every thing which he had been instructed to require; and having thus fulfilled his mission, he returned into Flanders, where, excepting the capture of Douay, Bethune, and Aire, the campaign of 1810 presented nothing remarkable. The emperor Joseph I. having died about this time, Prince Eugene, in concert with the empress, exerted his utmost endeavours to secure the crown to the archduke, who afterwards ascended the imperial throne under the name of Charles VI.

In the year following, 1711, the changes which had occurred in the policy, or rather the caprice, of Queen Anne, brought about an approximation between England and

France, and put an end to the influence which Marlborough had hitherto possessed with that princess. When this political revolution became known, Prince Eugene immediately repaired to London, charged with a mission from the emperor, and there made strenuous efforts to re-establish the credit of his illustrious companion in arms, as well as to re-attach England to the coalition. But all arguments and persuasions, whether founded on views of interest or sentiments of honour and consistency, having proved unavailing, the emperor found himself under the necessity of making the campaign of 1712 with the aid of the Dutch alone. The defection of the English, however, did not induce Prince Eugene to abandon his favourite plan of invading France. He had long been decided to make any sacrifice to accomplish this design, the conception of which originated as much, perhaps, in resentment as in a passion for glory. He therefore resolved, at whatever cost, to penetrate into Champagne; and in order to support his operations by the possession of some important places, he began by making himself master of Quesnoy. But the Dutch having been surprised and beaten in the lines of Denain, where Prince Eugene had placed them at too great a distance to receive timely support in case of an attack, he was obliged to raise the siege of Landrecies, and to abandon the project which he had so long cherished. This was the last campaign in which Austria acted in conjunction with her allies. Abandoned first by England and then by Holland, the emperor, notwithstanding these desertions, still wished to maintain the war in Germany; but the superiority of the French army prevented Eugene from relieving either Landau or Friburg, which were successively obliged to capitulate; and seeing the empire thus laid open to the armies of France, and even the hereditary states themselves exposed to invasion, the prince counselled his master to make peace. Sensible of the prudence of this advice, the emperor immediately entrusted Eugene with full powers to negotiate a treaty; and after some interviews, in which the prince and Villars interchanged expressions of esteem and admiration, there was concluded at Rastadt, on the 6th of March 1714, a peace which had long been anxiously looked for, and of which the nations of Europe had the greatest need.

After this happy event, Prince Eugene went to enjoy at Vienna some moments of repose. The emperor continued to show him marks of the most entire confidence; and from this time adopted no resolution, either in regard to the administration of the army, or that of the interior, without consulting him. But this kind of occupation did not suit the activity of Eugene; and although he was now advanced in years, his warlike humour had lost nothing of its vivacity. Sensible of the impossibility of Austria, situated as she was, resisting France, he had done all in his power to accelerate the conclusion of peace; but, by a contrary species of reasoning, he availed himself of a petty quarrel which the Ottoman Porte had with the Venetians to determine his master to espouse the cause of the latter. The emperor, having taken this step, appointed Eugene to command the army of Hungary; and at Peterwaradin, with a force not exceeding sixty thousand men, he gained a signal victory over the Turks, who had not less than a hundred and fifty thousand men in the field. This victory made a great noise in Europe, and all the Christian powers conceived themselves bound to rejoice on account of it. The pope sent to the victorious general the consecrated rapier, which the court of Rome was accustomed to bestow upon those who had triumphed over the infidels; and this extraordinary present was put into the hands of Prince Eugene by an envoy of his holiness. But the ensuing campaign, being that of 1717, was still more remarkable, on account of the battle of Belgrade. After having remained under the walls of that city, in a situation the most difficult imaginable; after having resisted, during a month, the efforts of a numerous garrison, as well as those of a hundred and fifty thousand Turks, with an army of only forty thousand men; and after having lost nearly the half of his troops by dysentery, and the fire of the Ottoman artillery, which plunged its shot even into his own tent; Prince Eugene gained one of the most complete victories of which there is any record or tradition, and soon afterwards forced Belgrade itself to capitulate. The attack which he ordered against forces six times more numerous than his own was really an act of despair. He had himself been seized with the cruel malady which was destroying his army, and all was consternation in the Austrian camp; yet at the very moment when he was believed to be on the eve of capitulating, he succeeded, by his constancy and daring courage, in obtaining a most decisive victory. The prince was wounded in the heat of the action, this being the thirteenth time that he had been hit upon the field of battle. On his return to Vienna he received numerous testimonies of gratitude, and, amongst others, a sword valued at eighty thousand florins, which was presented to him by the emperor. In the following year, 1718, after some fruitless negotiations with a view to the conclusion of peace, he again took the field; but the treaty of Passarowitz put an end to hostilities, at the moment when the prince had well-founded hopes of obtaining still more important successes than those which had illustrated the last campaign, and when he even flattered himself with reaching Constantinople, and dictating a peace on the shores of the Bosphorus. On his return to Vienna he was, as usual, received with every mark of esteem and admiration.

As the government of the Low Countries, formerly conferred upon Eugene, had now for some reason been bestowed on a sister of the emperor, the prince was appointed vicar-general of Italy, with a pension of three hundred thousand florins. From this time he occupied himself much more than he had ever done with the affairs of government; and Charles VI. habitually consulted him in all affairs of importance. He accompanied this monarch in several journeys, particularly to Prague, where Frederick I. of Prussia met the emperor by appointment, and testified the greatest admiration of the veteran warrior, by whom the latter was attended; and his influence seemed to be in all respects commensurate with his fame. During the ten years of peace which ensued, Eugene occupied himself with the arts and with literature, to which he had hitherto been able to devote little of his time. But the contest which arose out of the succession of Augustus II. to the throne of Poland having afforded Austria a pretext for attacking France, war was resolved on, contrary to the advice of Prince Eugene, whose last campaigns had taught him to dread the efforts of that power. Yet, although he had in the council declared his opinion in favour of peace, he was appointed to command the army destined to act upon the Rhine. This army, from the commencement, had very superior forces opposed to it; and if it could not prevent the capture of Philipsburg after a long siege, it at least prevented the enemy from entering Bavaria. Prince Eugene, having now attained his seventy-first year, no longer possessed the vigour and activity necessary for the command of armies; he himself perceived the change which time had wrought in his powers; and as he now longed for and required repose, he applied himself to bring about a peace, which was at length concluded on the 3d of March 1733. Having returned to Vienna, his health declined more and more, and he died in that capital on the 21st April 1736, leaving an

immense succession to his niece the Princess Victoria of Savoy.

Of a character cold and severe, Prince Eugene had almost no other passion than that of glory. He died unmarried, and without having ever evinced the slightest partiality for any woman, excepting, perhaps, the Countess de Bathiani, who, by the attractions of her wit and vivacity, appears to have consoled the last moments of his life. Although one of the greatest warriors of his time, military science is not indebted to him for any remarkable improvement. His operations were not directed according to any positive method, nor conformable to invariable principles; it was by sudden inspirations, and an admirable rapidity of *coup d'œil*, that he conducted himself on the ground according to the circumstances and the men with whom he had to deal; and upon all occasions he took the greatest pains to ascertain the character of the generals who were opposed to him. This system of tactics chiefly resembles that which we have seen displayed in the recent wars; it exhibits neither the prudence and circumspection of Turenne, nor the astonishing strategic ability of Frederick, in the difficult art of putting in motion and deploying columns and lines: it consists merely in an incessant activity and audacity, united with an admirable promptitude in perceiving and repairing faults. Despising the lives of his soldiers as much as he exposed his own, it was always by persevering efforts and great sacrifices that he obtained victory. To the Austrian armies he gave an eclat which they had never before possessed, and which, as it was reflected from his character alone, died with him; in fact, he could not sustain himself without efforts which wars so protracted and destructive rendered impossible upon the part of the people of Austria. This exhaustion, indeed, was long felt in the Austrian monarchy; and as that power has not had a single general since the time of Prince Eugene who can at all be compared with him, its armies have not subsequently been illustrated by any remarkable event, and the reputation of this general has consequently stood far above that of all other commanders in the imperial service. Prince Eugene, in truth, had a prevailing passion for war. Always on the march, in camps, or on the field of battle during more than fifty years, and under the reign of three emperors, he had scarcely passed two years together without fighting. It has been said that he loved letters and the arts; and the protection which he afforded to J. B. Rousseau has often been cited as a proof of this commendable taste. It is certain, indeed, that in his numerous expeditions, he had made an immense collection of objects interesting to science and art, as well as of valuable books and manuscripts; but it is evident that he never took time to examine them; and there is nothing to prove that he knew how to appreciate their value. He profited by war, which, in every point of view, prodigiously enriched him; and if he must be ranked with Turenne, Vendôme, and Catinat in regard to personal valour, he cannot be compared with them in point of disinterestedness and generosity. Prince Eugene was a man of the middle size, but, upon the whole, well made; the cast of his visage was somewhat long, his mouth moderate, and almost always open; his eyes were black and animated, and his complexion such as became a warrior. His funeral oration, composed in Italian by Cardinal Passionei, was translated into French by Madame du Boccage, 1759, in 12mo. But the most complete work on his life is the *Histoire du Prince Eugène*, Amsterdam, 1740, and Vienna, 1755, which was published anonymously, though it is now known to be the compilation of a M. de Mauvillon. It was from this production that the Prince de Ligne derived the greater part of the writing which he published in Germany in 1809, and which was twice printed the year following at Paris, under the title of *Vie du Prince Eugène de Savoie, écrite par lui-même*, in one vol. 8vo. There exists in German a history of Prince Eugene, which is little esteemed; and there was also published at Nuremberg, in 1738, a work entitled *Eugenius nummis illustratus*, which is of little value. But the Italian work on the Life and Campaigns of Prince Eugene, published at Naples in 1754, 8vo, is much more exact. We have also *Campagnes du Prince Eugène en Hongrie*, in 2 vols. 8vo; and *Histoire Militaire du Prince Eugene, du Duc de Marlborough, et du Prince de Nassau*, 2 vols. fol. by Dumont, and continued by Rousseau, Hague, 1729. The work of Father Ferrari, entitled *De Rebus Gestis Eugenii Principis Sabaudiæ, Bello Pannonico*, is much more remarkable for the purity of the style than for the accuracy of the facts. (J. B—E.)

EUGUBIAN, or Eugubine Tables, *Tabulæ Eugubinæ*, inscribed tablets in bronze, found in 1444 at La Schieggia, near Gubbio (*Eugubium*), in the duchy of Urbino. These tablets are seven in number, five of them containing inscriptions in Umbric, mixed with Etruscan, and the remaining two inscriptions in Latin characters. They were at first believed to be of very high antiquity; but it is now pretty generally agreed that they are not more ancient than the fourth century before the Christian era. The learned reader will find copies of these remarkable monuments in Dempster's *Etruria Regalis* (vol. i. p. 91, et seqq.), and also some curious details respecting them in the supplement to that work by the senator Buonarotti (vol. ii. p. 101). According to Lanzi, they refer entirely to the mode of sacrifice, the particular forms of prayer, and other religious rites of certain Umbrian communities, who were united in a sort of federal bond; but the explanations of the learned Italian are much too arbitrary and hypothetical to be of any authority; and, in point of fact, we are still as ignorant of the *language* of these inscriptions as when the tablets were first discovered, above four centuries ago. (See article Etruscans.) But as the character has proved less untractable than the text, an Etruscan alphabet has been constructed, by means of which we are enabled to read the words which as yet we cannot interpret. Previously to the time (1732) when Bourguet undertook this difficult task, several persons had attempted it, and failed. But, by carefully comparing the tablets in the Roman character with those in the Etruscan, the ingenious Frenchman discovered that the former were a compendium of the latter, and that many words were common to both sets; and, having obtained this key, he succeeded, by pursuing the comparison he had instituted, in constructing an alphabet which, though far from being complete, was yet much more perfect than any which had preceded it. Since the time of Bourguet, however, no further progress has been made in this confined but interesting field of inquiry; and as the language has hitherto baffled every artifice of interpretation, the contents of these curious monuments of antiquity still remain undeciphered. The discovery of a bilingual inscription, which is not an impossible event, would, however furnish the needful key, and lead directly to the solution of an enigma alike vexatious and interesting to the scholar. Should this ever happen, or should some rare effort of sagacity or miracle of fortune unexpectedly put any inquirer on the right road without such aid, we venture to prognosticate that the language of these inscriptions will be found to be radically Celtic, perhaps a dead dialect of that language, intermixed with terms of Pelasgic origin. That the Umbri were Celts, or at least of Celtic origin, there can be little doubt; and it seems equally certain that the Etruscans, who ultimately predominated over all the other tribes which from time to time had settled in

Etruria, were also, in part at least, of northern descent. It would therefore be strange indeed if in these inscriptions, five of which are in the Umbric mixed with the Etruscan character, no traces were found of that primitive language which successive immigrations from the north must have diffused over a considerable portion of the great plain of Italy. The Eugubine Tables were first published by Smetius, 1588; then by Gruter, *Inscript.* vol. i. p. 142. (Bourguet, Dempster, *De Etruria Regali;* and Lanzi, *Sag. di Ling. Etr.;* and Lassen, *Beit. zur Deut. der Eugub. Taf.* (J. B—E.)

EUHARMONIC. See Organ.

EULER, Leonard, professor of mathematics, member of the Imperial Academy of Petersburg, ancient director of the Royal Academy of Berlin, and fellow of the Royal Society of London, as also a corresponding member of the Royal Academy of Sciences at Paris, was born at Basil on the 15th of April 1707, of reputable parents. The years of his infancy were passed in a rural retreat at the village of Richen, of which place his father was minister. Being sent to the university of Basil, he attended regularly the different professors; and as his memory was prodigious, he performed his academical tasks with uncommon rapidity; but all the time he thus gained was consecrated to geometry, which soon became his favourite study. The early progress which he made in this science only gave new ardour to his application; and thus he obtained a distinguished place in the esteem of John Bernoulli, who was at that time one of the first mathematicians in Europe, as well as in the friendship of Daniel and Nicolas Bernoulli, who were already the rivals of their illustrious father. In 1723 Euler took his degree as master of arts, and delivered on that occasion a Latin discourse, in which he drew a comparison between the philosophy of Newton and the Cartesian system, which was received with the greatest applause. At his father's desire he afterwards applied himself to the study of theology and the oriental languages, and though these studies were foreign to his predominant propensity, his success was considerable; but, with his father's consent, he returned to geometry as his principal pursuit. He continued to avail himself of the counsels and instructions of John Bernoulli; he contracted, as already stated, an intimate friendship with his two sons, Daniel and Nicolas; and it was in consequence of these connexions that he became afterwards the principal ornament of the Academy of Petersburg. The project of erecting this academy, which had been formed by Peter the Great, was executed by Catherine I.; and the two young Bernoullis being invited to Petersburg in 1725, promised Euler, who was desirous of following them, that they would use their utmost endeavours to procure for him an advantageous settlement in that city. In the mean time, by their advice, he applied himself with ardour to the study of physiology, to which he made a happy application of his mathematical knowledge; and he also attended the medical lectures of the most eminent professors of Basil. This study, however, did not wholly engross his time, nor even relax the activity of his powerful and comprehensive mind in the cultivation of other branches of natural science. For whilst he was keenly engaged in physiological researches, he composed a dissertation on the nature and propagation of sound, and an answer to a prize-question concerning the masting of ships, to which the Academy of Sciences adjudged the *accessit,* or second rank, in the year 1727. From this latter discourse, and other circumstances, it appears that Euler had early embarked in the curious and important study of navigation, which he afterwards enriched with so many valuable discoveries.

Euler's merit would have given him an easy admission to honourable preferment, either in the magistracy or university of his native city, if both civil and academical honours had not been there distributed by lot. But chance having decided against him in regard to a certain situation to which he aspired, he left his country, set out for Petersburg, and was made joint professor with his countrymen Hermann and Daniel Bernoulli in the university of that city. At the commencement of his new career he enriched the academical collection with many memoirs, which excited a noble emulation between him and the Bernoullis; and this emulation always continued, without either degenerating into a selfish jealousy, or producing the least alteration in their friendship. It was at this time that he carried to a new degree of perfection the integral calculus, invented the calculation of sines, reduced analytical operations to a greater simplicity, and threw new light on all the parts of mathematical science. In 1730 he was promoted to the professorship of natural philosophy; and in 1733 he succeeded his friend Daniel Bernoulli in the mathematical chair. In 1735 a problem was proposed by the academy which required expedition, and for the solution of which several eminent mathematicians had demanded the space of some months. The problem was solved by Euler in three days, to the great astonishment of the academy; but the violent and laborious efforts it cost him threw him into a fever, which endangered his life, and deprived him of the use of his right eye. The Academy of Sciences at Paris, which in 1738 had adjudged the prize to his memoir concerning the nature and properties of fire, proposed for the year 1740 the important subject of the tides; a problem the solution of which required the most arduous calculations, and comprehended the theory of the solar system. Euler's discourse on this question was considered as a masterpiece of analysis and geometry; and it was more honourable for him to share the academical prize with such illustrious competitors as Colin Maclaurin and Daniel Bernoulli, than to have carried it away from rivals of inferior reputation. Rarely if ever did such a brilliant competition adorn the annals of the academy; and no subject, perhaps, proposed by that learned body, was ever treated with such accuracy of investigation and force of genius, as that which here displayed the philosophical powers of these three extraordinary men.

In the year 1741 Euler was invited to Berlin in order to augment the lustre of the academy which was there rising into fame. He enriched the last volume of the *Mélanges* or Miscellanies of Berlin with five memoirs, which make an eminent, perhaps the principal, figure in that collection; and these were followed, with an astonishing rapidity, by a great number of important researches, which are scattered throughout the memoirs of the Prussian academy, of which a volume was regularly published every year. The labours of Euler will appear more astonishing when it is considered, that whilst he was enriching the Academy of Berlin with a prodigious number of memoirs on the deepest parts of mathematical science, containing always some new views, often sublime truths, and sometimes discoveries of great importance, he did not discontinue his philosophical contributions to the Academy of Petersburg, which granted him a pension in 1742, and the memoirs of which display the marvellous fecundity of Euler's genius. It was with much difficulty that this great man obtained, in 1766, permission from the king of Prussia to return to Petersburg, where he desired to pass the remainder of his days. Soon after his return, which was graciously rewarded by the munificence of Catherine II., he was seized with a violent disorder, which terminated in the total loss of his sight. A cataract, having formed in his left eye, which had been essentially

damaged by a too ardent application to study, deprived him entirely of the use of that organ. It was in this distressing situation that he dictated to his servant, a tailor's apprentice, who was absolutely devoid of mathematical knowledge, his *Elements of Algebra;* which, by their intrinsical merit in point of perspicuity and method, and the unhappy circumstances in which they were composed, have excited equal applause and astonishment. This work, though purely elementary, discovers the characteristics of an inventive genius; and it is here alone that we meet with a complete theory of the analysis of Diophantus.

About this time Euler was honoured by the Academy of Sciences at Paris with the place of foreign member of that learned body; and after this, the academical prize was adjudged to three of his memoirs, *Concerning the Inequalities in the Motions of the Planets.* The two prize-questions proposed by the same academy for 1770 and 1772 were designed to obtain from the labours of astronomers a more perfect theory of the moon. Euler, assisted by his eldest son, was a competitor for these prizes, and obtained both. In this last memoir he reserved for further consideration several inequalities of the moon's motion, which he could not determine in his first theory, on account of the complicated calculations in which the method he then employed had engaged him. But he had the courage afterwards to review his whole theory, with the assistance of his son and Messrs Krafft and Lexell, and to pursue his researches until he had constructed the new tables, which appeared, together with the great work, in 1772. Instead of confining himself, as before, to the fruitless integration of three differential equations of the second degree, which are furnished by mathematical principles, he reduced them to the three ordinates, which determine the place of the moon; and he divided into classes all the inequalities of that planet, as far as they depend either on the elongation of the sun and moon, or upon the eccentricity, or the parallax, or the inclination of the lunar orbit. All these means of investigation, employed with such art and dexterity as could only be expected from analytical genius of the first order, were attended with the greatest success; and it is impossible to observe without admiration such immense calculations on the one hand, and on the other the ingenious methods employed by this great man to abridge them, and to facilitate their application to the real motion of the moon. But this admiration will become astonishment when we consider at what period and in what circumstances all this was effected. It was when he was totally blind, and consequently obliged to arrange all his computations by the sole powers of his memory and his genius; when he was embarrassed in his domestic circumstances by a dreadful fire, which had consumed the greater part of his substance, and forced him to quit a ruined house, every corner of which was known to him by a habit that in some measure supplied the place of sight;—it was in these circumstances, and under these privations, that Euler composed a work, which alone is sufficient to render his name immortal. The heroic patience and tranquillity of mind which he displayed need no eulogy here; and he derived them not only from the love of science, but from the power of religion. His philosophy was too genuine and sublime to stop its analysis at mechanical causes; it led him to that divine philosophy of religion which ennobles human nature, and is alone capable of forming a habit of true magnanimity and patience under suffering.

Some time after this the celebrated Wenzell, by couching the cataract, restored Euler's sight; but the satisfaction and joy which this successful operation produced were of short duration. Some instances of negligence on the part of his surgeons, and his own impatience to use an organ the cure of which was not complete, deprived him of vision a second time; and this relapse was accompanied with tormenting pain. With the assistance of his sons, and of Messrs Krafft and Lexell, however, he continued his labours; neither the loss of his sight nor the infirmities of an advanced age being sufficient to damp the ardour of his genius. Having engaged to furnish the Academy of Petersburg with as many memoirs as would be sufficient to complete its acts for twenty years after his death, he in the space of seven years transmitted to the academy above seventy memoirs, and left above two hundred more, which were revised and completed by the author of this notice. Such of the memoirs as were of ancient date were separated from the rest, and form a collection which was published in the year 1783, under the title of *Analytical Works.*

Euler's knowledge was more universal than could well be expected in one who had pursued with such unremitting ardour mathematics and astronomy as his favourite studies. He had made very considerable progress in medical, botanical, and chemical science; he was an excellent scholar, and possessed what is generally called erudition in a very high degree. He had read, with attention and taste, the most eminent writers of ancient Rome; the civil and literary history of all ages and all nations was familiar to him; and foreigners who were only acquainted with his works were astonished to find in the conversation of a man whose long life seemed to have been wholly occupied in mathematical and physical researches and discoveries, such an extensive acquaintance with the most interesting branches of literature. In this respect, no doubt, he was much indebted to an uncommon memory, which seemed to retain every idea that was conveyed to it, either from reading or meditation. He could repeat the Æneid of Virgil from the beginning to the end without hesitation, and indicate the first and last line of every page of the edition which he used.

But several attacks of vertigo, in the beginning of September 1783, which did not prevent his calculating the motions of the aerostatical globes, proved the forerunners of his mild and happy passage from this scene to a better. His death was sudden; he ceased to calculate and to live at nearly the same instant of time. Whilst he was amusing himself at tea with one of his grandchildren, he was struck with apoplexy, which terminated his illustrious career at the age of seventy-six. Euler, says Condorcet, was one of those men whose genius was equally capable of the greatest efforts and of the most continued labour; who multiplied his productions beyond what might have been expected from human strength, and who notwithstanding was original in each; whose head was always occupied, and his mind always calm. The nature of his pursuits, by withdrawing him from the world, preserved that simplicity of manners for which he was originally indebted to his character and his education; and he employed none of those means to which men of real merit have sometimes recourse in order to enhance the importance of their discoveries. It is true that fecundity such as his renders useless all the little calculations of self-love; but still great lucidity of mind and uprightness of character are necessary to trace, as he has done, the history of his thoughts, even when his investigations have proved fruitless, or the results disappointed the expectations which he had formed. Euler's constitution was uncommonly vigorous; his health was good; and the evening of his long life was serene, being sweetened by the fame which follows genius, the public esteem and respect which are never withheld from exemplary virtue, and several domestic comforts, which he was capable of feeling, and therefore deserved to enjoy.

The works which Euler published separately are, *Dissertatio physica de Sono*, Bâle, 1727, in 4to; *Mechanica, sive Motûs scientia, analytice exposita*, Petersb., 1736, in 2 vols. 4to; *Einleitung in die Arithmetik*, ibid. 1738, 2 vols. 8vo, in German and Russian; *Tentamen Novæ Theoriæ Musicæ*, ibid. 1739, in 4to; *Methodus inveniendi Lineas curvas, maximi minimive proprietate gaudentes*, Lausanne, 1744, in 4to; *Theoria motuum Planetarum et Cometarum*, Berlin, 1744, in 4to; *Beantwortung*, etc., or Answers to different Questions respecting Comets, ibid. 1744, in 8vo; *Neue Grundsætze*, etc., or New Principles of Artillery, translated from the English of Benjamin Robins, with notes and illustrations, ibid. 1745, in 8vo; *Opuscula varii argumenti*, ibid. 1746-51, in 3 vols. 4to; *Novæ et correctæ Tabulæ ad loca Lunæ computanda*, ibid. 1746, in 4to; *Tabulæ Astronomicæ Solis et Lunæ*, ibid. 4to; *Gedanken*, etc., or Thoughts on the Elements of Bodies, ibid. 4to; *Retung der Gottlichen Offenbarung*, etc., Defence of Divine Revelation against Freethinkers, ibid. 1747, in 4to; *Introductio in Analysin Infinitorum*, Lausanne, 1748, in 2 vols. 4to; *Scientia Navalis, seu Tractatus de construendis ac dirigendis Navibus*, Petersb. 1749, in 2 vols. 4to; *Theoria motûs Lunæ*, Berlin, 1753, in 4to; *Dissertatio de principio minimæ actionis, una cum examine Objectionum cl. prof. Kœnigii*, ibid. 1753, in 8vo; *Institutiones Calculi Differentialis, cum ejus usu in analysi Infinitorum ac doctrina Serierum*, ibid. 1755, in 4to; *Constructio Lentium Objectivarum*, etc., Petersb. 1762, in 4to; *Theoria motûs Corporum solidorum seu rigidorum*, Rostoch, 1765, in 4to; *Institutiones Calculi Integralis*, Petersb. 1768–1770, in 3 vols. 4to; *Lettres à une Princesse d' Allemagne sur quelques sujets de Physique, et Philosophie*, Petersb. 1768–1772, in 3 vols. 8vo; *Anleitung zur Algebra*, or Introduction to Algebra, ibid. 1770, in 8vo; *Dioptrica*, ibid. 1767–1771, in 3 vols. 4to; *Theoria motuum Lunæ nova methodo pertractata*, ibid. 1772, in 4to; *Novæ Tabulæ Lunares*, ibid. in 8vo; *Théorie complète de la construction et de la manœuvre des Vaisseaux*, ibid. 1773, in 8vo; *Eclaircissements sur les établissements en faveur tant des Veuves que des Morts*, without a date; *Opuscula Analytica*, Petersb. 1783–1785, in 2 vols. 4to.

EULOGY, encomium, panegyric; praise bestowed on any one on account of his virtues, valuable qualities, or services. The French *éloge* is usually a kind of funeral oration in honour of a celebrated person, and generally embraces a biographical account of the deceased.

The word eulogy is derived from the Greek εὐλογία, which signifies literally *good speaking*, *praise*, or *panegyric;* and which in the New Testament is employed in the sense of *blessing*, and of *thanksgiving*, as also to denote a collection of alms for the poor brethren. Hence in the ancient Greek Church the term was applied to small pieces of bread which were blessed and distributed among such as had not yet communicated. The Latin Church too, for many ages, had a similar custom; and thence arose the use of the consecrated wafer. The same name was also applied to loaves or cakes brought to church by the faithful to have them blessed. Eventually the use of the term passed to mere presents made to a person without any benediction.

EUMENES, a native of Cardia, a city in the Thracian Chersonesus, was born B.C. 360 and died in 315. At a very early age he was employed as private secretary by Philip king of Macedonia, and on the death of that prince he was confirmed in office by Alexander. It was in this capacity that he accompanied that monarch into Asia; and so highly did Alexander esteem him that he gave him for wife Artonis the daughter of Artabazus. Upon the death of Alexander, the provinces and armies were divided amongst his generals, and the countries assigned to Eumenes were Cappadocia and Paphlagonia, with the sea-coast of Pontus as far as Trapezus; but as they were not yet subdued, Leonatus and Antigonus engaged to put him in possession. Antigonus, however, disregarded the orders of Perdiccas; and Leonatus, having in vain attempted to induce Eumenes to accompany him to the assistance of Antipater in Europe, made an unsuccessful attack on his life. Eumenes, however, escaped his vengeance and joined Perdiccas, who assisted him in taking possession of Cappadocia.

About this time Craterus and Antipater, having reduced Greece, determined to pass into Asia and overthrow the power of Perdiccas. The first blow was aimed at Cappadocia; and in the emergency Eumenes was appointed commander of all the forces in the neighbouring countries. But to this Neoptolemus, one of the generals, refused to submit; and being defeated by Eumenes, he fled to Antipater and Craterus. The presence of Antipater was required in Cilicia, and the army destined to act against Eumenes was therefore commanded by Craterus and Neoptolemus. They were, however, completely defeated; Neoptolemus was killed, and Craterus died of his wounds, 321 B.C. The Macedonians receiving intelligence of the defeat of two of their generals by one whom they considered a stranger, only a few days after the death of Perdiccas, the Macedonian chiefs condemned Eumenes to death, and charged Antipater and Antigonus with the execution of their order. Eumenes was at first successful, but being defeated through the treachery of one of his officers, he fled to Nora, a strong fortress on the confines of Cappadocia and Lycaonia. Here he made a successful resistance, and was afterwards appointed by Olympias to command the army against Antigonus, whose intentions could no longer be misunderstood. He gained a battle against his adversary, but unfortunately lost the baggage and women belonging to his Macedonian phalanx. Antigonus offered to restore them on condition that the soldiers would surrender Eumenes into his hands; and having induced them to comply with the base proposal, he put him to death, in the fortieth year of his age. (Plutarch, *Life of Eumenes;* Nepos; Diodor. Sic. xviii. 30.) See MACEDONIA, and PONTUS.

EUMENES I. and II., the names of two kings of Pergamus. See PERGAMUS.

EUMENIDES (strictly, *the gracious goddesses*), an euphemistic appellation of the Furies. See FURIES.

EUMOLPIDÆ (*Sweet-singers*), the family of the priests of Demeter at Athens and Eleusis. They are said to have been descended from Eumolpus, a Thracian warrior and bard, the son of Neptune and Chione. Having been thrown into the sea by his mother, he was rescued by Neptune and educated in Ethiopia, whence he was expelled along with Ismarus his son, and fled to the court of the Thracian king Tegyrius. From Thrace he found it necessary to escape to Eleusis, where having joined the Eleusinians in a war with Athens, he was slain in battle along with his two sons. According to another account, he lived to preside over the Eleusinian mysteries which had been communicated to him by the goddess; and being succeeded in office by his son, the sacred duties continued ever afterwards to be discharged by members of his family. As sacred officers the hierophant and his attendants were distinguished by a particular dress; and besides attending to the celebration of the mysteries they were also entrusted with the dispensation of that traditionary law which regulated the punishment of religious offences. Occasionally they offered up the public prayers of the nation, and at the command of the people they gave utterance to the public curse imprecated upon political offenders. See MYSTERIES, and ELEUSINIAN MYSTERIES.

EUNAPIUS, a Greek sophist and historian, born at Sardis A.D. 347. In his native city he studied under the sophist Chrysanthius; but afterwards went to Athens, where he became a favourite pupil of Proæresius. He was the author of two works, one entitled *Lives of the Sophists*, and the other consisting of a *Continuation of the History of Dexippus*. The former work is still extant, but of the latter only excerpts remain. Both are written in an extremely inflated style, and both display traces of the most bitter enmity against the Christians.

EUNOMIANS, an Arian sect, so called from being the followers of Eunomius of Dacora in Cappadocia. Their leader studied theology under Ætius, and after having been deacon of Eudoxius at Antioch, was raised to the bishopric of Cyzicus, A.D. 360. From Cyzicus he was banished to Chalcedon, and from Chalcedon he was again exiled to

Halmyris in Mœsia. He spent the last days of his life at Cæsaræa and Dacora, where he died at an advanced age, A.D. 394. As a religious sect his followers adopted the extreme tenets of Arianism, denying not only that the Son was of the same but also of similar essence with the Father. From this their distinctive doctrine they were called Anomoians, in opposition to the Homousians or orthodox, and Homoiousians or semi-Arian party. (See ARIUS.) The works of Eunomius consist of a *Commentary on the Epistle to the Romans; an Exposition of Faith; a Defence of his Doctrine; and Epistles.* His defence is translated by Whiston in *Eunomianismus Redivivus.*

EUNUCH (εὐνοῦχος), an emasculated person. It appears from a law of Moses that the practice of emasculation was prior even to his time. (See Levit. xxi. 20; Deut. xxiii. 1.) From the remotest antiquity among the Orientals, as also at a later period in Greece, eunuchs were employed to take charge of the women, or, generally, as *chamberlains;* whence the name, οἱ την εὐνην ἔχοντες, *i. e.* those who have charge of the bedchamber. Their position in the harems of princes affording them the ready means of access to the royal person, it is not surprising that they were frequently enabled to exercise an important influence over princes, and even to raise themselves to stations of great trust and power. Hence the term eunuch in Egypt came to be applied to any *court* officer, whether a castratus or not. The vulgar notion that eunuchs are necessarily deficient in courage and in intellectual vigour is amply refuted by history. We are told, for example, by Herodotus, that in Persia they were far from being objects of contempt, but were frequently promoted to the highest offices. Narses, the famous general under Justinian, was an eunuch: such also was Hermias, governor of Atarnea in Mysia, to whose manes the great Aristotle offered sacrifices, besides celebrating the praises of his patron and friend in a poem (still extant), addressed to *Virtue.* (See Lucian's dialogue entitled *Eunuchus.*) To multiply instances were superfluous: the capacity of this class of persons for public affairs is strikingly illustrated by the histories of Persia, India, and China; and we need only to allude to the power exercised by the eunuchs under the later Roman emperors.

In the Gospel of St Matthew (xix. 12) we read of persons "who have made themselves eunuchs for the kingdom of heaven's sake;" an expression which apparently is an hyperbolism descriptive of such as lived in voluntary abstinence (compare Matt. v. 29, 30). This passage has, however, received a literal interpretation from some, as exemplified in the celebrated case of Origen, who acted upon the injunction—"Let him who is capable of doing this do it." But this species of extravagance was at its height in the second century, when there arose a sect called Eunuchs, who not only emasculated themselves, but also all those who fell into their hands.

The effect of early emasculation upon the voice, and its tendency to promote increase of stature, are well known.

EUPATOR, a name assumed by some of the kings of Asia among whom the vast conquests of Alexander the Great were divided.

EUPATORIA, or KOZLOV. See CRIMEA.

EUPATRIDÆ, in *Antiquity,* a name given by Theseus to the nobility of Athens, as distinguished from the Geomori and Demiurgi. By the establishment of Theseus, the Eupatridæ had the right of choosing magistrates, teaching and dispensing the laws, and interpreting religious mysteries. In all other matters the whole city was reduced to an equality. The Geomori were either free landholders or simply husbandmen, and inferior to the Eupatridæ in point of fortune: the Demiurgi were artizans, and fell short of the Eupatridæ in number. See ATTICA, vol. iv., p. 193.

EUPEN, a frontier town of Rhenish Prussia, government of Aix-la-Chapelle, and 11 miles S.S.W. of the town of that name. It stands in a pleasant valley on the Vesdre, an affluent of the Meuse, and is one of the principal manufacturing towns of Prussia. The manufactures are chiefly fine woollen cloths and cassimeres. Pop. (1849) 12,573, principally descendants of French Protestants, who took refuge here subsequently to the revocation of the edict of Nantes.

EUPHEMISM (εὐφημεῖν, *to speak well of*), in *Rhetoric,* a figure in which a delicate word or expression is substituted for one that is harsh or offensive; as in the use of "departed" or "deceased" for "dead." Among the ancients the use of euphemisms was very frequent, arising from a superstitious dread of using certain words and phrases that were regarded as ominous or unlucky. Hence Horace's "*male ominatis parcere verbis.*" For the same reason the Furies were called by the Greeks *Eumenides, q.d.,* the *gracious ones.*

EUPHONY, an agreeable sound; a smooth and elegant enunciation of words. In *Grammar* it denotes a kind of figure by which a letter is altered or suppressed, in order to obviate harshness of sound.

EUPHORBIUM, the resinous concrete juice of several species of Euphorbia. This substance possesses very active qualities, being extremely acrid, violently purgative and emetic, and dangerously stimulant when it enters the nose in the form of dust. It is imported from Africa and several parts of India in *serons* (skin-bags), in small, hollow, forked pieces. See BOTANY, Nat. Ord. 195.

EUPHORBUS, a famous Trojan, son of Panthöus. He was the first who wounded Patroclus, but himself perished by the hand of Menelaus, who hung his shield as a trophy in the temple of Juno at Argos. Pythagoras is said to have affirmed that he was the transmigrated soul of Euphorbus, and that his soul recollected many of its previous warlike exploits. In proof of his assertion, he identified at first sight the shield of Euphorbus in the temple of Juno.

EUPHORION, a distinguished poet and grammarian, was the son of Polymnetus, and was born at Chalcis in Eubœa, B.C. 274. He studied philosophy under Lacydes and Prytanis, and poetry under Archebulus the Therean. After amassing great wealth, he retired (B.C. 221) to the court of Syria, and there assisted Antiochus the Great in forming the royal library at Antioch, which it was intended should rival that of Alexandria; and in this employment Euphorion died. Only a few fragments of his works have been preserved; but from the opinions expressed by ancient writers, it appears that the erudite character of his allusions rendered him so obscure that he was difficult to be understood, and that he was constantly in search of archaic and obsolete expressions. As late as the times of the Emperor Tiberius, the works of Euphorion were still sufficiently popular. The fragments have been edited by Meineke under the title *De Euphorionis Chalcidensis Vita et Scriptis,* &c. Gedani, 1823. See also Clinton's *Fasti Hellenici,* vol. ii. p. 511; Fabricius, *Bib. Græc.,* vol. i. p. 594; Heyne, *De Euphorione, et Excurs.* iii. *ad Virg. Eclog.* vi. 64, and *Excurs.* v. *ad Æn.* ii.

EUPHRANOR, a celebrated painter and statuary of Greece, was a native of Corinthia, but from his having practised his art and acquired his renown at Athens, he is always identified with the Athenian school. In sculpture he produced a great number of pieces, from colossal life figures to drinking cups. Of the finest of these, a figure of Paris, a beautiful copy now exists in the Museo Pio-Clementino. His principal pictorial work was extant in the time of Pausanias in one of the porches of the Ceramicus. It represented on one side of the wall the twelve gods, and on the other Theseus as the founder of the equal polity of Athens. Euphranor was also the author of some works on colour and proportion, which seem to have been the characteristic excellences of his own pieces.

EUPHRATES, the most considerable river of western Asia, is formed by the junction of two great streams rising in the mountains of Armenia, pashalic of Erzeroum, and uniting in about N. Lat. 39., E. Long. 39. The Frat or northern branch has its principal sources about 20 miles N.E. of the town of Erzeroum; and the Murad, on the north declivity of the Arghi-dagh mountains, 45 miles N.E. from the nearest point of lake Van. The Euphrates flows first to the south, but, being driven westward by the Anti-Taurus and Taurus mountains, it works its circuitous way through narrow passes and over cataracts, until, breaking through a defile formed by the eastern extremity of Mons Amanus (Alma-dagh) and the north-western extremity of Mons Taurus, it reaches the plain country not far from Samosata (Sumeisat). It then winds south and south-east, passing the north of Syria, and the north-east of Arabia Deserta, and at length, after many windings, unites with the Tigris, and thus united, finds its termination in the Persian Gulf. In conjunction with the Tigris, it forms the rich alluvial lands of Mesopotamia, over which it flows or is carried by canals, and thus diffuses abroad fertility and beauty. At Baghdad and Hillah (Babylon), the Euphrates and Tigris approach comparatively near to each other, but separate again, forming a kind of ample basin, till they finally become one at Kurnah. Although occasionally much more, the breadth of the Euphrates varies between 200 and 400 yards, but for a distance of 60 miles through the Lemlun marshes the main stream narrows to about 80 yards. The general depth of the Upper Euphrates exceeds 8 feet. In point of current it is for the most part a sluggish stream; for, except in the height of the flooded season, when its flow approaches 5 miles an hour, it varies from $2\frac{1}{4}$ to $3\frac{1}{2}$, with a much larger portion of its course under 3 than above. Its general description for some distance below Erzingan is that of a river of the first order, struggling through high hills, or rather low mountains, making an exceedingly tortuous course, as it forces its way over a pebbly or rocky bed, from one natural barrier to another. As it winds round its numerous barriers, it carries occasionally towards each of the cardinal points a considerable body of water; and is shallow enough in some places for loaded camels to pass in autumn, the water rising to about $4\frac{1}{2}$ feet. The upper portion of the river is inclosed between two parallel ranges of hills, covered for the most part with high brushwood and timber of moderate size, having a succession of long narrow islands. The principal towns on its banks are Samsat, Haoroum, Romkala, Bir, Giaber, Deir, Rava, Anah, Hadisa, El Oos, Jibba, Hit, Hillah, Lemlun, Kurnah, and Basrah. The scenery above Hit, in itself very picturesque, is greatly heightened by the frequent recurrence of ancient irrigating aqueducts, beautiful specimens of art, which are attributed by the Arabs to the Persians when fire-worshippers: they literally cover both banks, and prove that the borders of the Euphrates were once thickly inhabited by a highly civilized people. From Hit to Babylon the black tent of the Bedouin is almost the only kind of habitation to be seen. This distance is cultivated only in part; the rest is desert, occasionally interspersed with clusters of date-trees. In descending, the irrigating cuts and canals become more frequent. Babylon is encircled by two streams, one above, the other below the principal ruins; beyond which they unite and produce abundance. For about thirty miles below Hillah both banks have numerous mud villages, shaded by date trees: to these succeed huts formed of bundles of reeds. The country lower down towards Lemlun is level and little elevated above the river; irrigation is therefore easy: in consequence, both banks are covered with productive cultivation, and fringed with a double and nearly continuous belt of luxuriant date-trees, extending down to the Persian Gulf. At one mile and a half above the town of Dewania is the first considerable offshoot from this hitherto majestic river; another takes place 22 miles lower; and nine miles farther—at Lemlun—it again separates into two branches, forming a delta not unlike that of Damietta, and when the river is swollen, inundating the country for a space of about 60 miles in width with a shallow sheet of water, forming the Lemlun marshes, nearly the whole of which is covered with rice and other grain when the river recedes (in June). Below Lemlun the Tigris sends a branch to the Euphrates, which is thus increased in its volume; and turning to the east, receives the chief branch of the Tigris, thence running in a single stream, under the name of the Shat-el-Arab, as far as the Persian Gulf. In this last part the river has a depth of from 3 to 5 fathoms, varies in breadth from 500 to 900 yards, and presents banks covered with villages and cultivation, having an appearance at once imposing and majestic. The length of the entire stream is 1400 miles. It is very abundant in fish. The water is somewhat turbid; but, when purified, is pleasant and salubrious. The Arabians set a high value on it, and name it Morad Sou; that is, Water of Desire or Longing. The river begins to rise in March, and continues rising till the latter end of May. The consequent increase of its volume and rapidity is attributable to the early rains, which, falling in the Armenian mountains, swell its mountain tributaries; and also to the melting of the winter snows in these lofty regions. About the middle of October the Euphrates has reached its lowest ebb, and ceasing to decrease, becomes tranquil and sluggish.

The expedition sent out by the British government, under the direction of Colonel Chesney, navigated the Euphrates in 1836 from Bireh-jik to its estuary, a distance of 1117 miles; and besides throwing much light on a country then very imperfectly known to Europeans, proved that there exist no serious obstacles to the navigation of that river by moderate-sized steamers thus far; and even for 88 miles above Bireh-jik to Beles, an important station in a commercial point of view.

The East India Company sent a small flotilla in 1841, under the command of Captain C. D. Campbell of their navy, to ascertain the navigability of the Euphrates. The expedition proved highly successful, having traversed the course of the stream for 1030 miles above its mouth. Mr Floyd, the surgeon of the flotilla, writing from Belis, June 6, 1841, says—"I am now near Aleppo, having completed the ascent of the Euphrates, without doubt one of the noblest rivers in Asia. Here, at a distance of a thousand miles from its embouchure in the Persian Gulf, it is 400 yards broad and very deep. The Euphrates differs very little from the Tigris up to Hilla, a Turkish Arab town, built near the site of ancient Babylon, except that its banks are much better cultivated, and in some the date-tree (the *Palma dactilifera*) adds to the picturesque meanderings of the river; while in others, a mosque, with its lackered dome rising from a group of willows, is a pleasing variety from the monotony of the surrounding district. The river is inclosed within a valley of high rocks, which extend from its source to below Hit. They are composed of gypsum, sandstone, and conglomerates, with mica and felspar. This climate is delightful, and produces all the varieties of European fruit, besides many of the tropical ones lower down the river. The only obstacle to the navigation consists in the remains of the water wheels used for irrigation. In the short space of 130 miles we found nearly 300 of these wheels, about one-third of which are in operation at the present day. They consist of large parapet walls built into the stream, directing the current of the river to the wheels, which are the most clumsy piece of mechanism, made of branches of trees, and have slung round them 150 clay vessels to raise the water in. The wheels are forty feet in diameter, placed at the end of an aqueduct raised upon well-built Gothic arches. It is surprising the quantity of water they raise to the surface. They cause a current of six or seven knots, with a fall of two or three

Eupolis || Eure.

feet where they are placed, so that the navigation of this part of the river is difficult and somewhat dangerous. The Tigris is now proved navigable to Mosul, the site of the ancient Nineveh; and the Euphrates to Baulus—I might say even to the heart of Taurus."

EUPOLIS, an Athenian poet of the old comedy, and in the judgment of Horace the greatest ornament of that school, was the son of Sosipolis, and was born B.C. 445. Nothing whatever is known of his personal history. With regard to his death, he is said to have been thrown into the sea by Alcibiades, who had suffered from his attacks. It is much more likely, however, and much more generally believed, that he fell at the battle either of Cynossema, B.C. 411, or of Ægospotami, B.C. 408. To a lively and fertile fancy Eupolis added a sound practical judgment, which prompted him to a thorough mastery of the mechanical part of his art. The result of his studies was that he was reputed to equal Aristophanes in the elegance and purity of his diction, and Cratinus in the command of the most bitter irony and pungent sarcasm. Very curious and complicated relations subsisted between Eupolis and Aristophanes, who accused each other with the bitterest virulence not only of imitation but of plagiarism. Some of these attacks will be found described in various parts of the Scholiæ upon Aristophanes. The plays of Eupolis are said to have numbered in all seventeen. Meineke gives the names of fifteen which he considers genuine, and an analysis of those whose subjects can be decided from the surviving fragments.

EUPOMPUS, one of the most celebrated of Greek painters, was a native of Sicyon, and a contemporary of Zeuxis and Parrhasius. He was the head of the Sicyonian school of art, and was held in very high esteem by his countrymen. When Lysippus the sculptor was beginning his career he consulted Eupompus as to whom he should take for his model. "Take nature herself for your model," replied Eupompus, "and be not shackled by the trammels of any predecessor." No mention is made of any piece of Eupompus except one—a victor in the games bearing a palm.

EURE, in the north of France, one of the five departments formed out of the old province of Normandy. It is bounded on the N. by the estuary of the Seine and the department of Seine-Inférieure, W. by Calvados, S. by Orne and Eure-et-Loir, and E. by Seine-et-Oise and Oise. It is sixty-five miles in length from E. to W., and its breadth varies from twenty-six to fifty-two miles, being between 48. 39. and 49. 29. N. Lat., and 0. 15. and 1. 45. E. Long. Area 2420 square miles. The surface is flat, with some ranges of low hills, none of them exceeding 300 feet in height. The three principal rivers by which it is watered are the Seine, the Eure, and the Rille. The Seine flows from S.E. to N.N.W. through this department, dividing it into two unequal parts. It afterwards touches the frontier at two or three points, and near its mouth forms part of the north boundary. The Eure, from which the department takes its name, rises in Orne, and flowing first east and then north, through Eure-et-Loir, falls into the Seine six miles below Louviers, after a course of ninety-three miles. The Rille likewise rises in Orne, and flows generally northward to its mouth in the estuary of the Seine. The climate is mild, but moist and variable. The soil is generally clayey, resting on a bed of chalk; but along the Seine there are some barren sandy tracts, quite incapable of cultivation. A great part of it, however, is very fertile and well cultivated. The chief kind of cereal cultivated is wheat, the growth of which occupies a larger space than rye, oats, and barley together. The quantity of grain produced is more than sufficient for the wants of the inhabitants. Flax is largely cultivated, and, from its length, fineness, and colour, is highly esteemed. Some hemp is also produced. The horses of the department, of the pure Norman breed, have always been celebrated, and, though they had nearly lost their high character, have of late been more carefully bred and much improved. The breed of cows is remarkably good; and the calves are much in request in the neighbouring departments. Sheep have been neglected, but have recently increased; and those on the coast, known as *Moutons du Pré Salé*, are highly valued for their excellent flesh. Of late years attempts have been made to improve the wool by a mixture of Merinos. Fruit is very abundant, especially apples, from which much cider is made. The vine is not much cultivated, cider being the principal beverage of the inhabitants.

Eure-et Loir.

This department abounds in iron ore, and is noted for its mining and manufacturing industry. Cotton, linen, and woollen cloths of every kind are fabricated. There are large establishments for making copper ware of all kinds, the various descriptions of paper, nails, pins, and needles, glass for windows and glass bottles, and jewellery and trinkets. These employments occupy the larger portion of the inhabitants. Such goods form the trade; in addition to which, fire-wood, timber, cattle, honey, wax, and corn are furnished to the district surrounding the department. Eure is divided into five arrondissements, as follows:—

Arrondissements.	Cantons.	Communes.	Pop. in 1851.
Evreux	11	261	120,374
Louviers	5	116	68,859
Les Andelys	6	134	64,717
Bernay	6	140	77,222
Pont Audemer	8	140	84,625
	36	791	415,777

EURE-ET-LOIR, a department in the northern part of France, between N. Lat. 47. 57. and 48. 57., and E. Long. 0. 44. and 2. 0.; being 68 miles in length from N. to S., and varying in breadth from 36 to 56 miles. It is bounded on the N. by the department of Eure, N.E. by Seine-et-Oise, S.E. by Loiret, S. by Loir-et-Cher, and W. by Sarthe and Orne. It is formed out of portions of the old provinces of Orleanais, Maine, and Ile-de-France, and has an area of 2361 square miles.

Loir comprises four arrondissements, &c., as follows:—

Arrondissements.	Cantons.	Communes.	Pop. 1851.
Chartres	8	166	111,617
Châteaudun	5	80	65,185
Dreux	7	135	71,268
Nogent-le-Rotrou	4	54	46,922
	24	435	294,892

The surface is generally level, with a few eminences principally in the south and west, but none exceeding 500 feet in height. The principal rivers are the Eure towards the N., and the Loir in the S.; but neither of these is navigable within the department. Small lakes are numerous. The climate is temperate and healthy, and not subject to sudden changes. The soil in the middle and west of the department is the best. It consists, for the most part, of thick layers of gray, yellow, or black clay, intermixed with sand, or of calcareous earth, and is on the whole fertile; but in the S.W., especially in the arrondissement of Nogent, it is sandy and dry, and many tracts of land are so poor as to be uncultivated. The agriculture is better conducted than in most of the departments of France; and the production of the various kinds of corn far exceeds the consumption, great quantities of grain being sent annually to Paris and other places. The wheat is remarkably fine, and is prized on account of its being easily preserved for a long time, and being well adapted for sea voyages. The cows are small, but yield good butter for the supply of Paris, and fat oxen and calves for the markets of Poissy and Sceaux. The sheep are numerous, but not remarkable, except some flocks whose wool has been improved by crosses with the Merino races. Wine is not extensively produced, nor of the best quality; but in some parts there is an abundant supply of apples, from which cider is made as the common drink of the inhabitants.

There are some iron mines, and granite, marble, and gypsum quarries. The manufactures are not extensive; but leather, paper, cotton goods of various kinds, serges, flannels, and other coarse woollens, hosiery, hats, caps, household linen, such as sheetings and table linen, and some earthenware, are furnished. The department draws its supply of fuel from its own woods, which cover about one-twelfth part of the whole surface.

EURIPIDES, one of the most celebrated of the tragic poets of ancient Greece, was the son of Mnesarchus and Clito. The place, as well as the date, of his birth has been a subject of considerable dispute among scholars. By some authorities he is said to have been born at Athens, B.C. 485, and to have belonged to the Phlyan demi of the Cecropid tribe; and in this opinion they are borne out by the testimony of the Arundel marbles. Others, again, maintain, that in the second Persian invasion the parents of Euripides were in the number of those who, on the approach of Xerxes, fled from Athens and took refuge in Salamis; and that the future poet was born there on the very day that the great naval battle was fought and won by his countrymen, B.C. 480. This fact is pretty well authenticated, though it is somewhat suspicious that the Athenians were careful to identify their three great tragic poets with the most brilliant day in the annals of their history. Æschylus, they said, at this time in the vigour of manhood, took part in the engagement; Sophocles, a boy of fifteen, was one of the choir which celebrated the exploits of the victors at the festival given after the battle; and Euripides was born while the action was still undecided. If the authority of Eratosthenes be admitted, who assigns the death of Euripides to the year 406 B.C., at which time he had reached his seventy-fifth year, the poet must have been born B.C. 481; and this date is adopted by Müller as the true one. It is almost equally difficult to discover the real social status of the poet's parents. It is said that his father Mnesarchus was an expatriated Theban; and Aristophanes, one of his bitterest enemies, asserts that his mother was a vendor of herbs, and a dishonest one, besides. These accounts may be safely rejected as false; but it is only inferentially that an approximation to the truth can be made. At the Thargalian festival he is known to have acted as cup-bearer to a chorus of noble Athenians engaged in its celebration; and as none but youths of good rank and family were admitted to this honour, it may be inferred that Euripides' origin was far from mean. His education also was entrusted to such masters as were highest in repute at that time in Athens; among others, it is said, to Prodicus, the fortune-hunting rhetorician of Ceos, who prided himself on having for his pupils none but the sons of noble families, or such at least as could afford to pay the exorbitant sums which he demanded for his instructions. In the gymnastic and other bodily exercises, then much in vogue in Greece, Euripides was at an early age trained with the greatest care. An oracle had declared that he would be crowned with sacred garlands, and much of the poet's youth was spent in the gymnasium with a view to distinction in athletic sports. At the early age of seventeen he offered himself as a competitor in the Olympic games, having already gained prizes at the Eleusinian and Thesean festivals. From some formal irregularity, however, he was not allowed to compete. To this early training is to be attributed that knowledge of athletic sports which the poet displays in his works, and which has been especially remarked (see Keble's *Academic Prelections*, p. 605) in his account of the combat between Eteocles and Polynices. Abandoning these pursuits, he betook himself at the age of eighteen to the study of painting, in which he attained a respectable, though not a remarkable, proficiency. Soon finding, however, that pictorial art was not his sphere, he devoted himself to literature, continuing his philosophical studies under the guidance of Anaxagoras, the influence of whose doctrines is traceable in many portions of Euripides' works, and was especially apparent in the lost tragedy of *Melanippus the Wise*. While still in his eighteenth year he made his first essay as a tragic author, though it is not known with certainty either that the tragedy was one of those that have descended to us, or that it was played in the theatre at all. Hartung conjectures, though on insufficient grounds, that the drama in question was the *Rhesus*, and that it was publicly produced. The first that we know with certainty to have been played under the poet's own name was the *Peliades*, which appeared B.C. 455. Fourteen years after this date, B.C. 441, Euripides gained the first prize for the first time. Though persecuted with unrelenting bitterness during the whole period of his sojourn at Athens, and exposed to the merciless sarcasm and satire of the devotees of the elder tragic school, he contested the palm sometimes successfully with Sophocles, the greatest of its living representatives, till the year 408. Worn out at length by age, the rancour of the small wits of the day, and, it is said, the unhappiness of his domestic relations, he retired in that year to the court of Archelaus, king of Macedon, by whom he was treated during the remainder of his life with the utmost courtesy and kindness. He did not live long, however, to enjoy the honours paid him by his royal friend, as he died two years after leaving his native city, B.C. 406. No sooner had the poet breathed his last than his countrymen, obeying the usual law of nature so well propounded by Horace, that

> Virtutem incolumem odimus
> Sublatam ex oculis quærimus invidi,

instantly recognised the greatness of their loss, and sought to bestow upon the poet's ashes the honours which they had always denied to himself during his lifetime. They implored the Macedonians to restore his bones, that they might rest in his native land; but that people, who had already buried him with splendid obsequies, and erected a sumptuous monument in his honour at Pella, refused to comply, and the Athenians had to content themselves with a cenotaph. So great was the grief of his life-long rival Sophocles for his death, that at the representation of his next play he made his actors play their parts uncrowned. The statue of the deceased poet was set up in the theatre, and a monument erected to his memory on the road leading from Athens to the Piræus. His fame abroad was so great, that, as Xenophon records, many of his countrymen who fell into the hands of their enemies on the disastrous expedition against Sicily were released by their masters when it was discovered that they could repeat many of the verses of the illustrious tragedian. On another occasion a knowledge of Euripides stood some of his countrymen in good stead. An Athenian ship, pursued by pirates, had directed its course for Caunus; but the inhabitants of that town refused to admit it within its port, until it was discovered that some of the crew were familiar with the heart-reaching passages in the dramas of their newly deceased countryman.

Many stories are to be found in the ancient writers concerning the worthlessness of Euripides' moral character; but they rest on such doubtful authority, and are in their own nature so ridiculous, as to carry their refutation on their very face. It is said, for instance, that he was guilty of bigamy, though in his relations to the sex he is known to have been one of the most austere of men; and even the manner of his death has been distorted so as to countenance this slander. The received account is, that he was torn to pieces by the hounds of king Archelaus, which it is said were set upon him by two envious rivals whom he had eclipsed in the good opinion of that monarch. The scandal-mongers of the day, however, declared that he met his death at the hands of some women while on his way to a criminal assignation. He must have been vicious, indeed, if, at the age of seventy-five, he indulged in practices generally believed to characterize the

hot season of youth. It is not improbable that these reports owed their origin to the severity and even gloom of his disposition. These qualities were remarkably prominent in the character of his teacher Anaxagoras, and it is likely that, along with the doctrines of that philosopher, Euripides imbibed a good share of his moral attributes. The stories of his hatred of women are in reality as devoid of foundation as those which insist upon his personal profligacy. Certain it is, that whatever his personal predilections were in reference to the fair sex, his artistic tendencies led him to devote much time and minute observation to the study of female character. No poet of ancient or modern times, Shakspeare alone excepted, had a keener eye for the delicate and subtle phases of the female mind in all its moods; and it is hard to think that the author of such fine conceptions as *Alcestis* and *Iphigenia* should have been the victim either of unrequited love or (as has been alleged) of conjugal infidelity, while his native city abounded with the noblest archetypes of female character, which, under names supplied by the old mythology, he delighted to observe and portray.

Though it would be extremely unjust to rank Euripides among the atheists of antiquity, it is nevertheless true that in his ideas of the world and a future state he adopted the doctrines of his master, and superadded a tinge of pantheism. Disregarding the practice of his great predecessors, Æschylus and Sophocles, he not only evinced no sympathy with the religious system of his country, but sometimes ran so directly counter to it as to lay himself open to the charge of impiety. It is therefore in vain that we search the works of Euripides for those lofty aspirations and that noble faith which distinguish the tragedians of the early school, especially Æschylus, who, though as strongly convinced as Euripides of the historic worthlessness of the myths which made up the body of the popular religion, yet accepted them, and in so doing strove to develop their latent import, and thus indirectly elevate and refine the moral nature of the people. C. O. Müller, however, says truly concerning Euripides, "with respect to the mythical traditions which the tragic muse had selected as her subjects, he stands on an entirely different footing from Æschylus and from Sophocles. He could not bring his philosophical convictions, with regard to the nature of God and His relations to mankind, into harmony with the contents of these legends, nor could he pass over in silence their incongruities. Hence it is that he is driven to the strange necessity of carrying on a sort of polemical discussion with the very materials and subjects of which he had to treat." Towards the close of his life Euripides acknowledged the inadequacy of his ethical creed, even for the requirements of his own moral nature, by renouncing it, and tacitly acquiescing in the established religion. Such was the only course open to him, and he adopted it as an escape from scepticism, just as some of the keenest and subtlest intellects of our own day have been obliged to seek refuge from rationalism, sometimes from utter unbelief, within the pale of the Roman Catholic communion. In this way he found rest for himself, but it was too late for him then to repair the injury he had done by unsettling the foundations of belief in the minds of his younger contemporaries. In a merely artistic point of view, moreover, the tragedies of Euripides afford a striking proof of the decay of the Athenian drama. The old mythology from which he drew his names and incidents is often altered and misapplied in the most arbitrary manner, and almost always so as to throw discredit or ridicule on ideas or persons invested by popular consent with all the respect and reverence willingly paid to old tradition. Thus in the *Helena*, one of the most entertaining of all his tragedies, he adopts the theory of Stesichorus, that the wife of Menelaus remained concealed in Egypt while Paris only carried off an airy phantom which bore a resemblance to her, and about which the Greeks and Trojans fought with each other for ten years. Menelaus himself is introduced upon the stage in rags (a favourite method with Euripides of treating his heroes, for which he was lashed by Aristophanes), and declaring himself perfectly satisfied. In the *Alceste*, one of the most powerfully pathetic of ancient or modern plays, and to which Milton touchingly alludes in his famous sonnet—

> Methought I saw my late espoused saint
> Brought to me like Alceste from the grave,
> Whom Jove's great son to her glad husband gave,
> Reserved by force from death, though pale and faint—

"Jove's great son" is delineated more in the character of a glutton or a modern prize-fighter than as the son of Alcmena, whose life was spent in the service of the inhabitants of earth. Others of the plays exhibit still more glaring incongruities. In fact, as has been observed by Schlegel in his lecture on Euripides, "Though he frequently affects the singular and uncommon, he is at other times too familiar, and the tone of the discourse assumes a confidential appearance, and descends from the elevation of the cothurnus to the level ground. In this respect, as well as in the picture of several characteristic peculiarities bordering upon the ludicrous, Euripides was a precursor of the new comedy, to which he had an evident inclination, as he frequently paints the men and manners of his own times under the names of the heroic ages. Hence Menander expressed a most marked admiration for him, and proclaimed himself his scholar; and we have a fragment of Philemon, which displays such an extravagant admiration that it hardly appears to have been seriously meant. 'If the dead,' says he, 'were still to have feeling, as some people suppose, I should hang myself for the sake of seeing Euripides.'" In a much-quoted passage, Aristotle declares that Euripides delineated men and manners as they are, and not as they ought to be. Though in this way the poet opened up to himself a much wider range, both of character and incident, than if he had limited himself to the old mythology, it is very questionable if he did not also lower the dignity of his art, the more especially as he chose for its vehicle the familiar parlance of everyday life. In thus bringing down his heroes to the level of his audience, he lost sight of the lofty aims to which tragedy had been directed by his predecessors. "How few of his pieces," says Schlegel, "turn on the constant struggle with the decrees of fate, or even on a heroic subjection to them. His characters generally suffer because they must, not because they will." Plato's dictum against tragic poets generally applies with peculiar force to Euripides. He said that they gave men too much up to the dominion of the passions, and rendered them effeminate by putting extravagant lamentations in the mouths of their heroes. It is not too much to say of Euripides, in particular, that the tendency of his plays is to seduce and corrupt the feelings by working on the more tender and susceptible emotions of the human breast. The excessive lengths to which he sometimes goes tend to produce a directly moral licentiousness. At other times he works out his catastrophes with such earnestness, and power, and pathos, that Aristotle pronounced him the most tragic of poets. He qualifies this judgment, however, by declaring in the next sentence that "he does not arrange other things well." Still the general impression of his pieces is sometimes extremely immoral. It may be that to this cause he owed part of his popularity; but he sometimes outstripped the modesty of nature, so far as to shock even his Athenian audience. This pandering to a depraved taste on more than one occasion involved him in serious trouble. An anecdote is told, that he introduced Bellerophon with a eulogium on wealth, in which he preferred it to all domestic happiness, and ended with observing, that if Aphrodite the Golden shone like gold, she was deserving the love of mortals; and that the spectators, taking umbrage at this, wished to stone both poet and actor. Euripides then sprang forward and called out, "Wait only

till the end; he will be requited accordingly." In others of his pieces the demoralizing tendency is not to be so easily counteracted. Lies and other bad practices are not only freely used, but even openly defended; especially when the author believes himself to have an excuse in the motives which actuate the teller of the falsehood. The ancients themselves condemned him for the alluring colours in which he depicted sensual vice, and the ingenious sophistry with which he sought to defend these delineations. Indeed, this latter characteristic may be said to distinguish all his writings, and give a sort of colour to the charge (only partly true however) under which he labours of being the poet of the sophists.

It is impossible here to analyse minutely the tragedies of Euripides. The general tendencies of the poet's works have been already pointed out in some detail. One power alone which Euripides possessed in a higher degree than almost any other poet of ancient or modern times requires to be specially mentioned; his power, to wit, of delineating female character. The beautiful self-devotion of Alceste is depicted with the most overpowering pathos; and the same may be said of the Iphigenia at Aulis, though the character of that heroine is not sustained to the end of the piece *qualis ab incepto processerit.* Nor is the poet less successful in his terrible exhibitions of female passion. The unnatural love of Phædra in the "Hippolytus," and the conflict of jarring passions in the mind of Medea, were first laid hold of by Euripides as affording materials for dramatic creations, and have been worked out by him with a subtlety (sometimes over-refined) and skill that no subsequent dramatist, Shakspeare excepted, has ever surpassed. In the last chorus of the "Troades," when the captive women, allotted to their respective masters, are leaving Troy in flames behind them, and proceed to the ships, the poet rises into the region of the sublime.

According to Varro, Euripides wrote seventy-five tragedies, of which only five were rewarded with the first prize; according to Thomas Magister, he wrote ninety-two, of which fifteen were thus successful. Of these tragedies eighteen (or, if the authenticity of the Rhesus be admitted, nineteen) have descended to our times. We subjoin a list of these, with the year in which they were first produced upon the stage:—*Alcestis*, B.C. 438; *Medea*, B.C. 431; *Hippolytus Coronifer*, 428; *Hecuba*, 423; *Heracleidæ*, (probably) 421; *Supplices, Ion, Hercules Furens, Andromache*, of doubtful date, but probably assignable to this period of the poet's life; *Troades*, 415; *Electra*, 413; *Helena*, 412; *Iphigenia at Tauris*, doubtful; *Orestes*, 408; *Phœnissæ*, the last produced at Athens by the poet; *Bacchæ*, brought out at the Macedonian Court; *Iphigenia at Aulis*, produced at Athens after the poet's death; *Cyclops*, of uncertain date. This play is interesting as the only extant specimen of the Greek satyric drama.

The editio princeps of Euripides, containing, however, only four of the plays, was published at Florence towards the close of the fifteenth century, under the editorial superintendence of J. Lascaris. In 1503 appeared the Aldine edition, in which the Rhesus was incorporated, and the Electra omitted. Of subsequent editions may be mentioned that of P. Stephens, Geneva, 1602; Barnes, Cambridge, 1694; Musgrave, Oxford, 1778; Beck, Leipzig, 1778–88; Matthiäe, Leipzig, 1813–29; and the variorum edition, Glasgow, 1821. Many of the separate plays have been edited by the greatest of modern scholars, as Porson, Elmsley, Walckenaer, Monk, Pflugk, and Hermann. There have been many translations, prose and poetical, of individual plays into several languages of modern Europe. The whole works have been translated into English verse by Potter, Oxford, 1814; and into German by Böthe, Berlin, 1800. There is also a complete English prose translation in Bohn's Classical Library. (Müller's *History of Greek Literature;* Schlegel's *Lectures on Dramatic Literature;* the essay on Euripides by the Rev. Edward Elder, M.A., in Smith's *Dictionary*, &c. &c.) (J. C—L.)

EURIPUS, now the strait of Egripo or Negropont, the narrowest part of the Eubœan Sea, which at the town of Chalcis contracts to so small a breadth that a bridge has been thrown across, connecting the island of Eubœa with the mainland. See Eubœa.

Euripus, in the ancient amphitheatre, was a trench that separated the seats of the spectators from the arena. It was designed as a defence against the elephants and other beasts exhibited.

EUROCLYDON (from Εὖρος, *the south-east wind*, and κλύδων, *a wave*), the name of a tempestuous wind which drove on shore at Melita (Malta) the ship in which St Paul was sailing to Italy (Acts xxvii.) It is supposed to be the wind commonly known among modern mariners by the name of a *Levanter*, which is not confined to any single point, but blows in all directions, from the N.E. round by the north to the S.E.

EUROPA, in Grecian mythology, the daughter of Agenor king of Phœnicia, from whom the continent of Europe is said to have derived its name. Her beauty was such that Jupiter himself became passionately attached to her, and, assuming the form of a bull, carried her away on his back over the sea to Crete. Her children, Minos, Sarpedon, and Rhadamanthus, were adopted by Asterlus, king of that island, to whom Europa was ultimately married.

EUROPE,

Comparative advantages and disadvantages of this division of the globe.

One of the great divisions of the globe. On a first view Europe appears to be less favoured by nature than the other quarters of the globe over which it has obtained so great an ascendancy. It is much smaller in extent; its rocky and mountainous surface does not admit of those noble rivers, like inland seas, which lay open the remotest regions of Asia and of America to the commerce of the world. Its vegetable productions are neither so various nor so exuberant; and it is poorly supplied with the precious metals, and with many of those commodities on which mankind set the greatest value. On the other hand, the climate of Europe, if it nourishes a less luxuriant vegetation, is of an equal and temperate kind, well adapted to preserve the human frame in that state of health and vigour which fits it for labour, and promotes the development of the intellectual and moral powers. The mountains that intersect its surface are barriers which enabled infant communities to protect themselves from violence, and to lay the foundation of arts, knowledge, and civilization. If it has few large navigable rivers, its inland seas and bays are, from their position and extent, the finest in the world, and have been the means of creating and nourishing that commercial spirit which has been one great source of its improvement. Though comparatively deficient in gold and silver, it is abundantly supplied with those useful metals and minerals which minister still more essentially to the wants of civilized life. Its apparent defects have become the source of real benefits, and the foundation of its grandeur. The disadvantages of its soil and climate have excited the industry of its inhabitants, given them clearer ideas of property, kindled a resolute spirit to defend their rights, and called into existence that skill and enterprise, and those innumerable arts

and inventions, which have enabled the inhabitants of this apparently barren and rocky promontory to command the riches and luxuries of all the most favoured regions of the globe. It is only in Europe that knowledge and the arts seem to be indigenous. Though they have appeared at times among some of the nations of Asia, they have either stopped short after advancing a few steps, or they have speedily retrograded and perished, like something foreign to the genius of the people. In Europe, on the contrary, they have sprung up at distant periods, and in a variety of situations; they have risen spontaneously and rapidly, and declined slowly; and when they disappeared, it was evident they were but crushed for the time by external violence, to rise again when the pressure had subsided. It is only in Europe, and among colonies of Europeans, that the powers of the human mind, breaking through the slavish attachment to ancient usages and institutions, have developed that principle of progressive improvement, of which it is impossible to calculate the final results. The rudest tribe in Europe, in which this principle has taken root, has a certain source of superiority over the most improved nations of Asia and Africa, where society remains perfectly stationary. If these nations are ever destined to advance in civilization, they must borrow from Europe those arts which she has invented, and which belong to civilized life in every climate. But the tenacious adherence of rude nations to the customs and superstitions of their ancestors, will not allow us to hope that the benefits of civilization will be rapidly diffused in this way. It is more probable that colonies from the older states of Europe will multiply as the population becomes more and more redundant; and that these colonies will carry the arts and knowledge, the language and manners, of Europe with them, to the other quarters of the world. From prejudices on both sides, it is found that two races, in very different stages of civilization, do not readily amalgamate; and it is therefore probable that the feebler inhabitants of these countries, like the American Indians, will be gradually displaced by the continual encroachments of the more energetic races of Europe.

Boundaries and extent.

Europe is bounded on the N. and W. by the Arctic and Atlantic Oceans; on the S. by the Mediterranean, the Black Sea, and Mount Caucasus; on the E. by the Caspian Sea, the river Ural, and the Uralian Mountains. The greatest length of the continent is from Cape St Vincent to the Sea of Kara, in the direction of N.E. and S.W., and is 3490 English miles. Its greatest extent from N. to S. is from Cape Matapan to Cape North, 2420 miles. The superficies of Europe, including the Açores, Iceland, Nova Zembla, and all its other islands, is 3,700,000 English, or 2,800,000 geographical square miles; and the length of its coast line is about 16,000 miles.

Climate.

The climate of Europe is distinguished by two peculiarities. It enjoys a higher mean temperature than any of the other great divisions of the world in the corresponding latitudes; and it is not subject to such violent extremes of heat and cold. These advantages it owes chiefly to its numerous seas, inland bays, and lakes, which render its temperature similar to that of islands; and partly also, according to Humboldt, to its situation at the western extremity of the greatest range of dry land on the surface of the globe; the western sides of all continents being warmer than the eastern. Europe lies almost entirely within the temperate zone, not more than one-fourteenth part of its surface being within the arctic circle. Only a very small part of it is uninhabitable from cold, and it nowhere suffers much from excessive heat. The mean temperature at its southern extremity, in the latitude of 36°, is about 66° of Fahrenheit; and at Cape North, in the latitude of 71°, where the mean temperature is 32°, the cold is not greater than in the latitudes of 55° or 56° on the east coasts of Asia and America. Hence Europe is habitable at a higher latitude by 12° or 14° than either of these continents.

There is a difference of the same kind between the temperature of the sea-coasts of Europe and the interior. In islands, and on the sea-coast, the mean temperature of the year is higher, and the heat is more equally distributed through the different seasons. As we advance from the coast eastward the mean annual temperature diminishes, but the heat of summer and the cold of winter increase. Thus London has the same mean annual temperature as Vienna, but it has the summer of St Petersburg, and the winter is warmer than at Milan. The Mediterranean, the Baltic, and inland lakes, produce the same effect as the ocean, in an inferior degree. The following table shows, I. The temperature of the year, and the various seasons, in places having the same latitude; II. The different distribution of heat through the various seasons in places having the same mean annual temperature.

Places.	Mean Temperature						
	Of the Year.	Winter.	Spring.	Summer.	Autumn.	Warmest Month.	Coldest Month.
I. *Lat.* 56.							
Edinburgh...	47·8	38·6	46·4	58·2	48·4	59·4	38·3
Copenhagen.	45·6	30·8	41·2	62·6	48·4	65·0	27·2
Moscow.......	40·2	10·8	44·0	67·1	38·3	70·6	6·0
Lat. 48.							
St Malo.......	54·4	44·2	52·2	66·0	55·8	67·0	41·8
Vienna.......	50·6	32·8	51·2	69·2	50·6	70·6	26·6
II. *Lat.*							
Dublin 53·21	49·2	39·2	47·3	59·6	50·0	...	...
Prague 50·2	49·4	31·4	47·6	68·9	50·2	...	...

Mountains.

The mountains of Europe are more numerous in proportion to its extent than those of the other great continents, but they are of less elevation than the mountains of America and Asia. The highest and the most extensive chains in Europe run generally in the direction of east and west, and are placed near its southern shores. The central mass of the Alps, with which all the other mountains in the south of Europe are connected, forms the summit of the continent, and determines the position of the surface and the courses of most of the rivers.

Alps.

The principal mass of the Alps extends in a semicircle from Nice, on the shores of the Mediterranean, to Trieste, on the Adriatic, a distance of 550 miles. Southward of Mont Blanc the Alps consist of a single chain, with many lateral branches, which lie chiefly on the west side; but immediately to the eastward of Mont Blanc the principal chain divides into two, which inclose the sources of the Rhone. These meet again at St Gothard, and on the east side of it part into three chains, one of which loses itself in Bavaria, another in Austria near Vienna, and the third terminates near Trieste. A lateral chain of no great elevation passes eastward, and connects the Alps with the mountains of European Turkey. Smaller branches connect the Alps with the Bohemian and Carpathian Mountains on the north, with the Vosges and Cevennes on the west, and, through the latter, with the Pyrenees. The Apennines are but a prolongation of the Alps on the south. Mont Blanc, the loftiest of the Alps, and the highest mountain in Europe, has an elevation of 15,680 English feet; and Mont Rosa, the Jungfrau, the Schreckhorn, and several other summits, approach to this height. The elevation of the chain diminishes towards both extremities. In general, the escarpments, or steepest sides, are turned towards Italy, and the lateral and subordinate branches are most numerous, and extend farthest, on the opposite side. The central chain of the Alps consists chiefly of granite, gneiss, sienite, and other crystalline rocks. Among the lateral ridges, to the westward of St Gothard, calcareous rocks belonging to the

chalk and greensand abound, and a large area is covered by the Molasse and other tertiaries. On both sides are found great deposits of gravel, and large detached blocks or boulders, often at a vast distance from their original situations. Eastward from St Gothard the central chain is accompanied on each side by a calcareous chain of great elevation. Though the summits of the Alps are steep and rocky, and the higher valleys are filled with glaciers, there is much good soil below. The vine grows at the height of 1600 feet above the sea, the oak at the height of 3390, corn at 4200 feet, and the larch at 6720 feet. At 6400 feet above the sea we have the climate of Lapland in latitude 68°, so that a degree of latitude in the northern half of the temperate zone in Europe corresponds to an elevation of about 290 feet. The lower limit of perpetual snow, according to Humboldt, is at the height of 8760 feet, in the latitude of 46°.

Pyrenees. The chain of the Pyrenees, which is next to the Alps in elevation, runs in the direction of east and west. Its length is about 240 miles; but, if we include the Cantabrian Mountains, which continue in the same line without interruption, the whole length will be about 500 miles. The central chain of the Pyrenees proper is of granite, but the most elevated summits are of secondary limestone, and lie on the south side of the granite. Mont Perdu, esteemed the loftiest of the whole range, consists of fetid limestone, and rises to the height of 11,270 feet. The south side of the Pyrenees is rugged and precipitous; but on the north there is a gradual descent to the plains of France by a series of parallel ridges diminishing in height. The Cantabrian Mountains are lower than the Pyrenees, and present their steepest sides to the north. There are four other chains of mountains in Spain, all running in a direction approaching to east and west, and all connected with one another and with the Pyrenees. The highest of these is the Sierra Nevada, the southmost, one of whose summits rises to the height of 11,660 feet. The lower limit of perpetual snow on the Pyrenees is at the height of 8960 feet. The red pine grows at the height of 7480 feet, which is about 700 feet higher than any species of trees on the Alps.

Apennines. The Apennines form an uninterrupted chain 750 miles in length, extending from the south-west termination of the Alps near Nice to the Straits of Messina. The southern extremity in Calabria consists chiefly of granite, gneiss, and crystalline rocks. From the Gulf of Tarentum, northward to the Alps, the prevailing rocks in the central ridges belong to the chalk, greensand, and probably the oolitic formations, which are flanked by tertiary deposits, and in some parts by volcanic tufas. The most considerable elevations are about the middle of the chain, where Il Gransasso rises to the height of 9570 feet.

Carpathians. The Carpathian and Sudetic Mountains, with the Erzgebirge and Boehmerwald, may be considered as forming one continued chain, the length of which, from the point where it strikes the Danube in Hungary, to the point where it strikes the same river in Bavaria, is about 1200 miles, exclusive of the transverse branches which separate Moravia from Bohemia and Hungary. The declivities of this long range of mountains are steepest on the south side. The elevations are lowest on the west, and generally increase as we advance eastward, till we come to the sources of the Theiss in the north of Hungary, after which they again decline. The Fichtelberg, at the westmost point of the chain, is 4030 feet high: Schneekoppe, the highest of the Sudetic Mountains, is 5280 feet, and Lomnitz in Hungary, the loftiest of the whole range, is 8460 feet. None of these mountains rise to the region of perpetual snow, the lower limit of which, according to Wahlenberg, is about 60 feet above the summit of Lomnitz. The rocks of these chains consist of granite, gneiss, and silurians, associated with greensand and oolites. Corn and fruit trees are said to grow at a greater height upon the Carpathians than upon the Alps, though the latter are two degrees farther south.

Dofrines. The chain of the Dovrefeld, Dofrines, or great Scandinavian Alps, is about 1000 miles in length, and has a general elevation of from 3000 to 6000 feet. The altitude of Skagstlos Find, the highest mountain of the chain, is 8400 feet. These mountains consist almost entirely of the older rocks, and present their steepest sides to the west. On Sulitelma, the highest mountain of this chain in Lapland, in latitude 67. 10., the lowest limit of perpetual snow is at the height of 3500 feet.

Urals. The Urals, or Uralian Mountains, which form the north-eastern boundary of Europe, extend from N. to S. through 20° latitude, with a breadth of about 40 miles. They rise very imperceptibly from the plains on both sides, and, where they are crossed by the road from Moscow to Siberia, the ascent and descent are so nearly imperceptible that, were it not for the precipitous banks alongside of them, the traveller would hardly suppose he was crossing a range of hills. The general elevation of that part of the range seems not to exceed 1350 feet, and the base on which it rests is itself 900 feet above the level of the sea. To the north of 58° 20′ there are several summits that rise to 2500 feet; but the higher part of the range is situate to the N. of 59°, and the highest of all, the Daneshkenkamen lies to the N. of 60°. The chain consists of palæozoic formations resting upon, and penetrated by igneous rocks. They contain much gold, which is procured by washing the thick masses of gravel resting on their flanks. Towards the S., the Urals diverge into or are connected with a number of small ranges that extend to the shores of the Caspian Sea and the Aral, and into the steppes of the Kirghiz, and even seem to be connected with the Ust-Urt, or High Plain, that rises to an elevation of 770 feet between the two seas. The Urals are rich in minerals, especially in gold and platina, but these are found in most abundance on the eastern or Asiatic side of the range. The mountains of Nova Zembla may be considered as a prolongation of the Urals. Their principal summit is Glassowsky, which has an elevation of about 2500 feet above the level of the sea.

Caucasus. The great range of Caucasus, which is now assumed to be the south-eastern boundary of Europe, extends in a north-westerly and south-easterly direction along the north-east coast of the Black Sea, and across the isthmus, terminating with a series of low hills in the peninsular promontory of Abcheron on the W. side of the Caspian Sea, along which its diverging branches form a large *Daghestan*, or hill country. The length of the principal chain is about 700 miles, with a breadth varying from about 60 to 140. The loftiest summits are found near the middle part of the chain, and are covered with perpetual snow. Elburz, the highest peak, has an elevation of 17,796 feet; Kasbec, the next highest, of 15,345; and the crest of the pass of Dariel, through which the only practicable road is carried, between Vladi-Kaukas and Teflis, rises to 8000 feet. The snow-line along the chain is between 10,000 and 11,000 feet above the level of the sea. The mountains of the Crimea, though separated from the Caucasus by the strait of Yenikaleh, and the alluvial delta of the river Kuban, would seem to be a prolongation of the chain, separated by some volcanic convulsion. This, however, may be considered doubtful, as there are no ignigenous rocks at all in the Crimea, so far at least as yet known, while granite is to be found in the Caucasus. The geological structure, however, of the Caucasus is very various. A considerable portion of the higher regions consists of white limestone, with ridges of black slate. The loftiest peaks are composed of granite, hornblende, schistes, porphyry, and trachytes. Many parts of the range are exceedingly craggy and precipitous; but, in other places, are found level plains and very beautiful and fertile valleys.

Europe.

Mountains of Turkey.

A long mountain range extends in an irregular curve from the Adriatic to the Black Sea, in the latter of which it terminates with *Emineh Burun*, or Cape Hæmus. The western portion, however, of the range properly belongs to the Dinaric Alps; and the Turkish *Balkans* (ancient *Hæmus*) begins near the sources of the river Lepentz, 21° E. Long., a point from which two great ranges diverge, one to the south, forming the ancient Pindus, while the Hæmus or Balkan range extends eastward, with a general elevation of less than 5000 feet, though a few of its summits reach the limit of perpetual snow; and the Tchar-dagh, the culminating point, rises to about 9700 feet. The range is broken through by numerous ravines, deep and narrow, and of the most terrific appearance; but there are also several practicable passes. The south side of the range consists of argillaceous schist, and is much more precipitous than the north side, which is calcareous. The range is well wooded, and believed to be rich in minerals. Near the east end a minor range, called the Little Balkan, diverges in a south-easterly direction, and, running parallel to the shores of the Black Sea, terminates near the Bosphorus. From the Tchar-dagh the Pindus extends southwards, dividing Albania from Rumelia, and forming a long range of wild hill-country with many lofty summits. To the south, it is connected with the mountains of Greece, which divide that country into a number of valleys and promontories. But the loftiest range is the Despoto-dagh, which is connected with the Balkans near 42° N. Lat. and 24° E. Long., and extends eastward between the basin of the river Maritza and the shore of the Archipelago. Its summits reach an elevation of 8000 feet, and it is chiefly composed of crystalline slates, gneiss, granite, and granular limestone.

Mountains of France.

Besides the Alps, which form its south-eastern border, and the Pyrenees, which divide France from Spain, there are in France several mountain ranges of considerable elevation. The Cevennes, the Forez, and the mountains of Auvergne, form together a group that divides the low country on the Mediterranean and the basin of the Rhone from the plains that extend westward to the Atlantic Ocean and the Bay of Biscay. The elevation of most of the summits is only between 3000 and 5000 feet; but in Auvergne, the Plomb-de-Cantal rises to 6093 feet, and the Puy-de-Sancy to 6221. Between France and Switzerland the range of Jura has nearly the same elevation; and further north the range of the Vosges divides the basin of the Rhine from that of the Moselle, but it is comparatively low, its summits ranging from about 1400 feet to 4000, and the loftiest rising only to 4693 feet above the level of the sea. From the plateau of Langres, in the department of the Haute Marne, a ridge of high ground, scarcely rising into hills, proceeds westward, between the Seine and the Loire, terminating in Finistere, while other ridges extend northwards into Belgium, separating the valleys of the Moselle, the Meuse, and the Marne.

Mountains of Britain.

The mountains of Britain are comparatively insignificant. They extend in a long range, or series of ranges, with many divergencies and interruptions, along the west side of the island, about 630 miles in length; but it is only in Wales and the north-western parts of England and Scotland that they attain an elevation comparable to that of even the lowest of the continental ranges we have mentioned. Snowdon, in Caernarvonshire, the highest mountain in Wales, rises only to 3570 feet; Helvellyn and Scafell, in Cumberland, to 3055 and 3166; Ben Nevis and Ben Muck-Dhui, in Scotland, to 4370 and 4390. They consist principally of primary and transition rocks.

Great Plain.

The Pyrenees, the Cevennes, Forez, Vosges, Jura, Alps, Apennines, Bohemian and Hercynian Mountains in Germany, Carpathians, and the Balkans, form together, as we have seen, a long range of high ground, inclosing many elevated valleys, and leaving between them and the shores of the Mediterranean Sea only a series of long narrow stripes of lowland. To the northward, however, Europe sinks into an immense plain, which extends all the way from the German Ocean and the North Sea to the Ural and Caucasian Mountains, and the shores of the Caspian and Black Seas. This plain would seem to have formed, since the commencement of the tertiary period of geology, though perhaps not all at the same time, the bed of the sea; for it is everywhere covered with tertiary formations and marine drift, and contains the fossil remains of animals that could only have lived in salt water. It includes the whole basins of the Baltic and White Seas; and the Scandinavian mountains would seem to have formed a large island bordering it on the N.W. The south-western portion of the plain is traversed by the large rivers that flow northwards from the Alps, and the Bohemian and Sudetic Mountains, which form the watershed between it and the basins of the Danube, the Rhone, and the Po; but eastward the watershed between the Baltic and the Caspian and Black Seas, only a few hundred feet in elevation, may be traced from a spur of the Carpathians, near the source of the Dneister, through the Russian provinces of Volhynia, Grodno, Minsk, Smolensk, Bialistock, Pskov, Twer. Novgorod (where it forms a sort of plateau, and rises into the Valdai Hills, the highest of which is only 1370 feet above the level of the Baltic Sea), and Vologda, to the Ural Mountains at the sources of the Petchora. The northern slope, forming the basin of the White Sea, possesses a barren soil and a cold climate, and towards the north stretches out into immense plains, covered with moss, marshy in summer, frozen in winter, only interrupted with a few rocky ridges. The southern slope improves in quality as it advances southward, and the middle region is a country of great fertility; but farther south this fertile region is separated from the Black Sea and the Caspian by the *steppes*, the surface of the higher portion of which is in general only about 200 feet above the level of the sea, though towards the Caspian it sinks much lower. Throughout the whole space occupied by the higher steppes, which extend westward from the Don and the Manytsh, along the Sea of Azof and the Black Sea, including three-fourths of the Crimea, and crossing the Dnieper westward along its right bank, till they meet the outskirts of the fertile regions of Little Russia, there is nothing to be seen but a coarse, rank grass, except in the hollows along the river banks, which produce a finer vegetation. The soil of the lower steppes, which extend along the Caspian Sea from the river Ural to the foot of Caucasus, with a breadth of from 250 to 300 miles, is covered with a fine sand mixed with shells, producing no trees or shrubs, but only at certain seasons a scanty grass. It is everywhere strongly impregnated with salt, as if the region had recently been, what there is every reason to believe it was, the bed of a sea.

Volcanoes.

Europe contains several volcanic regions, in some of which the volcanic agency is still active, while in others it has been long quiescent at least, if not extinct. A volcanic belt is believed to extend through Central Asia, and Asia Minor, the Archipelago, Greece, Naples, Sicily, the southern parts of Spain and Portugal to the Açores. In the Archipelago, the island of Santorin has been the grand centre of volcanic action for the last 2000 years; and the neighbouring island of Milo is also a volcano of recent aspect, though the epochs of its eruptions are not known. On the eastern shore of Sicily rises the stupendous cone of Etna or Mongibello, to the height of 10,873 feet, composed entirely of volcanic products, and known to have been in activity for nearly 2500 years. To the northward of Etna, the islands of Stromboli, Vulcano, and Vulcanello, in the Lipari group, are still active, throwing out continually both fire and smoke. To the south-west of Sicily the island of Pantellaria is entirely volcanic, and covered with prodigious quantities of lava, pumice, and scoriæ. Livy mentions (Book 39) that an

Europe.

island was said to have risen out of the sea near Sicily in the year 183 B.C., and in A.D. 1831 a volcanic island actually rose from the sea, between Sciacca and Pantellaria, but soon disappeared, being washed away by the waves. On the shore of the Gulf of Naples stands Mount Vesuvius, a volcano in constant activity; while to the westward of that city there is a volcanic region, including the island of Ischia, where the fire has been quiescent since the sixteenth century. Further north, round Rome, there are several extinct volcanic craters, most of which are now filled with water, forming so many beautiful though unwholesome lakes. Near the coast of Valencia, in Spain, the islands of Columbretes are the remnants of an extinct crater, and the traces of another volcanic region are to be found near Olot in Catalonia. The Açores (if they should be reckoned to Europe) are all apparently of volcanic origin, but contain no active volcanoes. Along the whole line of this volcanic belt, earthquakes are frequent and destructive. On each side of the line of greatest commotion there are parallel belts of country where the shocks are less violent. At a still greater distance, as far as the foot of the Alps, there are spaces where the shocks are rarer and much feebler; though while we are writing (January 1855) we have learned that two severe shocks of an earthquake were felt at both Nice and Turin, early in the morning of 29th December 1854. Beyond these limits again all the countries of western Europe are liable to slight tremors, at distant intervals of time; but these may be considered as mere vibrations. Shocks of this kind have been felt in England, Scotland, northern France, and Germany, particularly during the tremendous earthquake that destroyed Lisbon in 1755.

Besides the volcanoes that are still active, or have been so within historic times, there are traces of extinct volcanic action in different parts of Europe. The plain of Limagne, in Auvergne, in Central France, forms the base of a long chain of volcanic cones and domes, which, to the number of 70, form a zone of nearly 20 miles in length by 2 in breadth, and varying in height from 500 to 4000 feet. The whole of these cones present the same general character, that of well-defined craters, inclosed by regular cones, on whose sides the lava currents may be traced, as easily as on those of Vesuvius. Appearances of the same kind are found near Velay, in the Viverais. Near the Rhine the chains of the Vogelberg and Westerwald are formed of volcanic products; and the Eifel, a group of hills near the left bank of the Rhine, in the Prussian government of Aachen, or Aix-la-Chapelle, exhibits all the signs of extinct volcanic action, in its conical elevations, lava streams, and round deep craters now filled with water.

Far to the north-west of the mainland of Europe, the island of Iceland forms a volcanic region apart. The whole island appears to be of volcanic formation; there are several volcanoes still in full activity, and in the interior there are vast tracts covered with lava, scoriæ, and volcanic sand. From the beginning of the twelfth century there is clear evidence that, during the whole period, there has never been an interval of more than forty, and very rarely one of twenty years, without either an eruption or a great earthquake. Some eruptions of Mount Hecla have even lasted six years without intermission; but from 1783 that volcano remained quiescent till 1845, when it broke out anew. Earthquakes have often shaken the whole island at once, causing great changes in the interior; and new islands have often been thrown up near the coasts. In the intervals between eruptions, innumerable hot springs give vent to subterranean heat, and solfataras discharge copious streams of inflammable matter. In the south-western part of the island, nearly a hundred intermittent springs of steam and boiling water, the celebrated Geysers, are said to be found within a circle of two miles. The island of Jan Mayen, between Iceland and Spitzbergen, contains an active volcano; and the mountain of Sarytcheff, in the northern island of Nova Zembla, is the most northern volcano at present known.

Rivers.

Europe is well watered with rivers, but they are mere brooks compared with the mighty streams of Asia and America, and, from the unevenness of the surface, afford in general no great extent of inland navigation. The Danube, the largest river that is entirely in Europe, is about 1500 miles in length, and drains an area of 370,000 square miles. But the Amazons, though only twice the length of the Danube, drains a surface seven times as large, and equal to four-fifths of the continent of Europe; and, as the quantity of rain that falls in tropical countries is much greater than in northern latitudes, it is probable, notwithstanding the increased evaporation there, that the Amazons conveys more water than all the rivers of Europe put together. If we divide the length of the Danube into a hundred parts, the length of the principal rivers of Europe, expressed in these parts, will be as follows: Danube, 100; Volga, 130; Dnieper, 72; Don, 69; Rhine, 49; Elbe, 42; Vistula, 41; Loire, 37; Tagus, 32; Oder, 31; Rhone, 30; Seine, 23; Po, 21; Tiber, 10; Thames, 9.

The courses of the great rivers show the fall of the country through which they flow, but it would be absurd to take the average of the fall per mile from the measurements of their whole lengths, for, with the exception of the Volga, and other rivers of Russia, the early parts of their respective courses are among mountains, or in elevated valleys, where, and from which, the fall is very rapid; and it is only when taken from the points where they leave their mountain cradles and reach the plains, that such an average will truly indicate the extent and degree of the general slope of the continent. The source of the Volga is only about 560 feet above the level of the Caspian Sea, into which it flows, and the length of its course being at least 2000 miles, without any serious rapids, the average of its fall is consequently very regular, and little more than three inches a mile; but, the direct distance being only 900 miles, the slope of the country exceeds seven inches a mile. The source of the Danube, in Suabia, is about 2176 feet above the level of the Black Sea; but its fall is in several places very rapid, particularly between Passau and Vienna, and at the *Iron-gate*, through which it passes from the plains of Hungary to the low level of Wallachia. The average fall, therefore, of such a river would be a most fallacious index of the configuration of the whole length of country through which it flows. Its course is indeed through a series of terraces, separated by deep falls. The sources of the Rhine, in the heart of Switzerland, have an elevation of more than 7000 feet, but when it reaches the Lake of Constance it has already fallen to 1300. From that lake to Basel, where it leaves the mountains, it falls more than 500 feet, and even further down it still flows with great impetuosity, falling 400 feet more before it reaches Strasburg, a distance of only 70 miles. The average, however, of its fall from the latter city to the sea is only about one foot a mile. The elevation of the *Elbbrunnen*, or sources of the Elbe, in Bohemia, is 4260 feet, but the river falls so rapidly, within a short distance, that, after passing the northern mountain border of Bohemia, its elevation is found to be, at Dresden, only 280 feet. The average fall from that point to the sea is less than a foot a mile. The elevation of the source of the Oder is 1705 feet, but at Breslau it has already fallen to 370, and the average fall of the remainder of its course is likewise about a foot a mile. The elevation of the source of the Vistula we have not been able to learn, but as it is navigable from Podgorze, near Cracow, to the sea, its average fall is probably much the same as that of the Elbe or the Oder.

Few of the rivers of Europe are of much importance as means of communication and transit. The Volga becomes navigable at Rief, about 70 miles from its source, and so continues to the Caspian Sea, a distance of more than 2000

Europe.

miles, following the course of the river. It is the great highway of Central Russia, so many as 5000 loaded boats annually descending its stream; but as it ends unfortunately in an inland lake, it is of no use for the transport of other foreign wares than the produce of the sandy and barren regions that surround the Caspian. The Volga is so connected with the other great rivers and the lakes of Russia by canals, that there is uninterrupted navigation from the Baltic to the White Sea, the Black Sea, and the Caspian. The Don has a course of 900 miles, but has so many shallows as to be nowhere navigable for large or sharp-bottomed vessels. The Dnieper, the next largest river of Russia, has a course of 1000 miles, and is navigable from Smolensk to Ekaterinoslav; but, further down, its channel is so obstructed with rocks and falls for 150 miles, that navigable communication between the sea and the inland provinces through which it flows is completely cut off. The Danube becomes navigable at Ulm, 1500 miles from its mouth; but between Passau and Vienna it flows among mountains, and navigation is rendered difficult by the rapidity of the stream, and the frequent occurrence of rocks, shoals, eddies, and whirlpools; and, in leaving Hungary, through a narrow gorge of 60 miles in length, which it has cut for itself across the mountains that inclose that country, it falls in a series of rapids, the lowest of which is the famous Irongate, through which the stream rushes with great rapidity in a narrow channel, between stupendous rocks, ending in a series of whirlpools, eddies, and smaller falls. Here navigation was considered to be effectually stopped; but we have just learned (Jan. 1855) that steamboats have at last been constructed so as to be considered capable of passing these rapids in safety, and that they will be immediately put upon the river. It is also proposed to cut a channel through the rocks 1200 yards long, 40 feet wide, and 6 feet deep, which will give plenty of additional depth for the steamers and other loaded vessels. The number of workmen to be employed on this gigantic undertaking is 2000, and the work will extend over a period of six years, at a cost of two millions of florins. So numerous, besides, are the windings of the Danube through the comparatively level plains of Hungary, that between Presburg and the Black Sea, a direct distance of 650 miles, the course of the river actually measures 1200. The Rhine is navigable above the lake of Constance, but the navigation is stopped by the Rheinfall near Schaffhausen. From that point to Basel it is not very easy or always practicable; to Strasburg it is not free from danger, but further down the river becomes a fine navigable stream, not quite free indeed from difficulty and risk, particularly in the deep and narrow gorge which it passes through between Bingen and Coblentz; but below Coblentz the channel is uninterrupted and free from danger. Between the Rhine and the Danube there is a navigable communication by means of the rivers Meyn and Altmuhl, which are connected by the Ludwig's canal in Bavaria. The Elbe, and its tributary the Moldau, are both navigable even in Bohemia, and from their confluence to the sea there is no serious interruption. The Oder is navigable downwards from Silesia, and is of the utmost importance as the channel of conveyance for the productions of that country to the sea. Breslau, Frankfurt, and Stettin, three of the principal commercial towns of Prussia, stand on its banks, and it is connected by canals with the Vistula, the Havel, and the Spree. The Vistula is, like the Oder, the principal channel of transit between the Baltic Sea and the Polish provinces of Austria, Russia, and Prussia, and begins to be navigable at Podgorze, near Cracow.

These are the only rivers that seem to require notice as navigable streams in a general survey of Europe, though there are many others of great importance to the several countries in which they are found, as the Thames, the Tyne, the Clyde, the Rhone, the Po, &c.

Europe.

Islands.

The islands of Europe, including Nova Zembla and Iceland, occupy a space equal to 280,000 square miles, or one eleventh part of the surface of the continent; and of this space the area of the British isles amounts to rather less than one half. The Black Sea is the only large sea connected with Europe in which there are no islands worthy of notice.

Seas. Mediterranean.

The Mediterranean, the noblest inland sea in the world, forms the southern boundary of Europe, separating it from Africa, and partly also from Asia. It may be considered as the bottom of a vast basin formed by the Pyrenees, Alps, Balkans, Taurus, Libanus, and Atlas. These mountains are everywhere near its shores, which are consequently narrow and much inclined. Hence there are no such extensive plains as Hungary or Poland near the coast of this sea, and hence also no very large rivers fall into it except the Nile; and altogether it receives a smaller quantity of water from rivers than the Black Sea or the Baltic, though six times larger than either. Its length is about 2350 miles, its breadth is extremely various, and its surface (exclusive of the Black Sea) is nearly equal to 1,000,000 of square English miles, or something less than a third part of the continent of Europe. It is generally of great depth; and its numerous islands, which have uniformly a rocky surface, appear to be the summits of marine mountains.

Baltic

The Baltic, the greatest inland sea that is entirely in Europe, is about 1200 miles long, of very unequal breadth, and presents a surface of 175,000 square miles, exclusive of islands. It occupies the bottom of another large basin, 850 miles in breadth, and 1400 in length, extending from the Norwegian mountains on the north and west, to the Carpathians on the south, and to the high lands in which the Dnieper, the Don, and the Volga rise, on the east. This basin, equal to one-third of the surface of Europe, has a very different character from that of the Mediterranean. The mountains are not very elevated, and are so placed as to leave a large tract of land very little inclined between them and the Baltic, over which, especially on the south side, many considerable rivers flow with a gentle current. Hence the country round the Baltic is much more level than round the Mediterranean; lakes are numerous in the low grounds, from the want of declivity; the sea itself is comparatively shallow, and receiving a much greater quantity of river water, it is much less salt. The commerce of the Baltic is annually interrupted by the ice, which endures four months in the Gulfs of Bothnia and Finland. The whole of this inland sea has sometimes been frozen over for a short time, but this is of rare occurrence.

Black Sea.

The Black Sea, which belongs only partly to Europe, is 700 miles long and 380 miles broad, and, including the Sea of Azof, presents a surface of 170,000 square miles, being almost of the same magnitude as the Baltic. It derives four-fifths of its water from Europe, and is curiously distinguished from the other seas of this quarter of the globe, by its being almost totally destitute of islands.

White Sea.

The White Sea is 450 miles in length, of a very irregular figure, and occupies a space equal to 35,000 square miles. It receives some considerable rivers, but is frozen during six months of the year.

Lakes.

The lakes of Europe are numerous, and are of two kinds; those which lie in cavities at the foot of high mountains, and which are generally deep, such as the lakes in the Alps, on the east side of the Norwegian mountains, and among the mountains of England and Scotland; and those which are formed in level countries from the want of a sufficient declivity to carry off the water, such as the lakes in Finland, Poland, and Brandenburg. Four-fifths of the lakes of Europe are in the country round the Baltic.

Vegetable productions.

The soil of Europe has not the extremes of luxuriance or sterility which belong to the soil of the other great continents. If it does not yield the rich fruits of tropical cli-

Europe. mates, it is not deformed by burning sands like Africa, or by pestilent swamps like America. It does not pour forth its riches spontaneously, but, soliciting the care and the labour of man, it requites his industry with what is necessary to supply his wants; and, by exercising and sharpening his powers of mind, has given birth to those arts which place the productions of the most favoured climates at his disposal. Many of the plants which have been domesticated in Europe are natives of distant countries. The vine, the olive, and the mulberry, are said to have been brought from Syria by the Greeks; the Arabians introduced cotton; maize was received from the Indian tribes of America; the walnut and the peach come from Persia; the apricot from Armenia; and the sugar-cane and orange from China. There are not very many plants belonging to the tropical regions that absolutely refuse to grow in Europe, but an enlightened economy finds other productions more profitable. Besides sugar and cotton, the banana, the orange, citron, fig, pomegranate, and date, grow in the south of Europe. But the more delicate fruits are confined to southern latitudes, and disappear one by one as we advance northward. And it is worthy of remark, that the zones in which they grow generally follow the lines of equal summer heat, and run obliquely across the continent in the direction of south-west and north-east. If a line be drawn on the map from Brest to Konigsberg, skirting the southern shores of the English Channel and the Baltic, the zones that limit the growth of different plants will run nearly parallel with this line. This holds generally in the south and middle of Europe; but in the extreme northern parts, and especially with regard to plants that require a moderate heat continued for a considerable time, the lines that limit the growth of certain vegetables seem to follow a different course, and decline towards the south as we advance eastward, in consequence of the increasing severity and length of the winter. It is scarcely necessary to say, that the zones, traced as proper for different plants, only mark the limits within which their cultivation is found advantageous. Most of them will grow beyond these limits; but they either require some peculiar advantages of soil and situation, or they are less profitable than other kinds of produce.

The sugar cane, one of the most desirable tropical plants, grows in Sicily and the south of Spain, in the latitude of 37° and 38°. The culture of it, which was once extensive in the latter country, has not yet been entirely abandoned, even since sugar was procured from the West Indies. Cotton is cultivated in the south of Spain on a small scale, to a greater extent in Sicily, the south-east angle of Italy, and in Greece and its isles, as high as the latitude of 41½°; we find it again at Astrakhan, in the latitude of 46°. The orange and the lemon come to perfection in the west of Europe, only in the countries to the south of the Pyrenees and Apennines, within the latitude 43° in Spain, and 44° in Italy. The olive does not succeed on the west coast of France in the latitude of 43°, but grows as far north as 44° or 45° on the east of France, and in Italy. Attempts to raise it at Astracan, in latitude 46°, have not succeeded, on account of the rigour of the winter. The fig and the pomegranate, which accompany the olive in the west of Europe, are found in the Crimea in the east, at the latitude of 46°, where the olive will not grow, a proof that these trees bear the winter cold better. The climate proper for maize is found to terminate on the west coast of France at 45½°; on the Rhine at 49°; on the Elbe at 50° or 51°. Rice has nearly the same geographical range, but requires a peculiar soil and situation. The culture of the vine extends as far north as the latitude of 47½° on the Atlantic coast; on the Rhine to 50½°; and on the Oder to 52°. In Russia it grows as far north nearly as 52°, but is not cultivated beyond 50°. The mulberry generally accompanies the vine. The limits of the culture of the common cerealia are not so well defined, as the necessities of man oblige him to raise corn under the most unfavourable circumstances. In a general point of view, however, the parallel of 57° or 58° may be regarded as the northern limit of the cultivation of wheat in Europe. It is raised as far north as 60° or 61° in Finland, but only in some favoured spots. In Russia, generally, it is chiefly confined to the provinces under the latitude of 57°. The hardier cerealia, rye, oats, and barley, are cultivated in some sheltered situations on the coast of Norway, as high as the latitude of 69° 55′. But on the east side of the Norwegian mountains these grains scarcely ripen in the latitude of 67° or 68°; and farther east, in Russia, it has been found impossible to carry cultivation of any kind beyond the latitude of 60° or 62°. Barley, which accommodates itself better than any other grain to these high latitudes, by shortening the period of its growth, is sown and reaped within the space of seven or eight weeks. But the introduction of potatoes promises to be of vast advantage in these cold regions, as this plant thrives and yields a produce of thirty or fifty fold in places where grain often will not ripen. Peaches and apricots succeed with much care as far north only as the latitude of 50° in Russia; melons as far as 52°. The plum and the cherry grow wild as far north as 55°, but are carried farther by cultivation. Fruit trees and the oak terminate in Sweden, at Geffle, in the latitude of 61°; but the pine and the birch advance within the arctic circle; and the former grows to the height of 60 feet in the latitude of 70°. The blackberry and the whortleberry grow in Lapland, and the gooseberry even in Greenland. Tobacco is extensively cultivated over the greater part of the continent of Europe, from Sicily to Sweden. Flax and hemp have as extensive a range as corn, but they are raised in the greatest perfection between the latitudes of 45° and 60°.

We have stated that the superficial extent of Europe is about 3,700,000 square miles. If we draw a curved line from a point in the Uralian Mountains, about the latitude of 60° or 61°, to the west coast of Norway, in the latitude of 69°, passing through the Lake Onega, and a little to the northward of the Gulf of Bothnia, this line will mark the extreme limits of cultivation, and will cut off a space equal to 550,000 square miles, or nearly one-seventh of Europe. The space cut off, however, is not entirely useless, as a part of it produces pasturage and wood. The cultivation of rye, oats, and barley, is confined to the region south of this line, and includes more than five-sixths of Europe; but in the northern parts of this zone only a very small proportion of the land will bear corn. The region adapted to the cultivation of wheat comprehends about four-sevenths of Europe, and includes all the densely peopled parts. The region of the vine extends over three-sevenths of Europe.

Metals and minerals. Europe, in proportion to its extent, is probably richer in mineral wealth than the other quarters of the globe. It contains all the metals except platina; and though it affords gold and silver only in limited quantities, iron, copper, lead, with coal and salt, commodities of greater value to society, are abundantly and widely distributed. The mountains, consisting of primary and transition rocks, are the great depositaries of these mineral treasures.

Iron is found in all the chains of mountains in Europe. The richest mines are in the Dofrefeld, or Scandinavian Alps. But rich mines are also found in the Alps of Styria, Carinthia, and Bavaria; in the Pyrenees, the Vosges, the Cevennes, the coal districts of Britain, the Urals, the Carpathians, the Hartz, and many other places.

Copper is also widely distributed, though less abundant than iron. The richest mines are in Hungary, in the Carpathian Mountains. It abounds also in the Saxon and Bohemian Mountains, in the Dofrefeld, the Urals, the north of England, and the Alps; and it is found in the Vosges, the

Pyrenees, and other mountains of Spain, in the north of Germany, and in Tuscany.

Lead exists in the Alps, Carpathians, Pyrenees, Cevennes, Vosges, the British mountains, and the Uralian chain.

Tin is found only in a few places in Europe. The richest mines are in Cornwall; next to these are the mines in the Erzgebirge. It is also found in Hungary and Spanish Galicia.

Mercury, like tin, is confined to a few places. The mines of Idria, in Austria, which yield 8000 to 10,000 quintals per annum, are the most productive in Europe. There are also considerable mines at Deux Ponts, in the Palatinate; in the Spanish province of La Mancha; and in Transylvania.

Gold is widely diffused through Europe, but generally in such quantities as not to repay the expense of working. It is wrought, however, in the Carpathians, the Urals, the Dofrefeld, and the Alps. Anciently there were rich mines of gold in Spain and Greece.

Silver is more abundant than gold, though less widely distributed. There are productive mines of this metal in the Erzgebirge, the Carpathians, the Urals, the Norwegian Dofrefeld, and in Sardinia. It is found also in the Alps, the Vosges, and the Sierra Morena.

Of coal, the richest mines are found in the north and west of England. It abounds also on both sides of the middle region of Scotland; in Ireland; in the Netherlands; in one-fourth part of the French territory; and occurs more sparingly in Saxony, Hanover, Denmark, Sweden, Russia, Hungary, Bohemia, Moravia, Silesia, Bavaria, Austria, Franconia, Westphalia, Swabia, Catalonia, and some other parts of Spain, in Portugal, and in Sardinia. After Britain, France and Belgium are the countries in Europe best supplied with this mineral.

Salt is procured from the waters of the ocean, and, in the interior of Europe, from numerous salt mines and salt springs. The most productive salt mines in Europe are those in Poland, on the north side of the Carpathians, and those in Salzburg, on the north side of the Alps, both of which belong to Austria. There are also extensive depositaries of mineral salt in Transylvania and Hungary; in Valentia, Navarre, and Catalonia, in Spain; in Cheshire in England; and in Bavaria and Switzerland. Salt springs are numerous along the sides of primitive mountains in most countries of Europe. The most extensive salt mines of Russia are in Asia; but very large quantities of salt are collected from the *tuzlas*, or salt-lakes in the Crimea.

Antimony, cobalt, zinc, manganese, sulphur, alum, and a great variety of other mineral productions, are found in Europe; but it is unnecessary to specify their localities.

It is observed that the Alps, Pyrenees, Carpathians, and other mountain chains which run east and west, are richest in metals on the south side; while the Dofrines, Urals, and others which run north and south, are richest on the east side. Of the mountain chains of Europe, the Apennines are the poorest in metals, the Carpathians probably the richest.

Animals.

The animal kingdom of Europe is less varied than the vegetable. In the north, the white bear and the blue fox, the peculiar natives of the arctic regions, appear at times on the coasts of Russia and Lapland, and vast numbers of foxes inhabit Nova Zembla. The rein-deer abounds in Lapland, but can scarcely live to the south of 65°. In Russia, owing to the greater coldness of the climate, it is found as low as 63°. It forms the chief wealth of the inhabitants of those dreary regions. The lemming, a curious migrating animal, lives between the 55° and 65°; and the glutton is observed in the same region. The elk, an animal every day becoming scarcer, frequents Lithuania, and even some parts of Prussia, but is seldom found farther north than 64°. Rats and mice are not to be seen in the most northerly parts of Lapland, though they abound everywhere else.

The strongest horses and beeves are found in the great plains which extend from Moldavia and the Ukraine to Denmark and Flanders; they are found so far north as 64°. In Lapland, however, the ox is even found at 71°, and in Iceland there are horses even beyond the polar circle. The *urus* or *aurochs* (wild ox) is still occasionally seen in Poland. In the same region, and through the whole of central Europe, there is a breed of sheep originally the same as those of Spain and England. The ass, though far from being reckoned a delicate animal, does not bear cold so well as the horse. In Europe it is rarely seen beyond 52°. The climates most favourable to the ass are those between 20° and 40°. There he grows large and handsome, and is lively and docile; but farther north he degenerates, becoming always more and more puny, dull, and stupid.

The wild goat, the chamois, and the marmot frequent the great mountain ranges of middle Europe, the Alps, the Pyrenees, the Carpathians, and the Balkans.

The animals that are found in the middle region are also, for the most part, common to the south. The ox and the horse in Italy, if well fed, are as stout as any in the Ukraine or in Holstein. The Arab horse was brought into the south of Europe by the Moors and the Turks; and perhaps from it have sprung the Andalusian and other varieties. It is still less doubtful that the buffalo has been imported from Asia into Southern Europe. A particular species of sheep in Sardinia, and another in Candia, are supposed to be indigenous. The Arabian camel has been introduced into Tuscany. The Bactrian camel thrives in the steppes of the Crimea and southern Russia, which likewise feeds large herds of Tartar horses.

Different races of inhabitants.

Europe is peopled by several very distinct races of men, distinct in respect of physiological characteristics, as well as of language. It would be quite out of place here, however, to discuss the principles of anthropology, ethnology, glossology, and comparative philology, or any of the important questions respecting the origin and affinities of nations, that have occupied the attention of the cultivators of these branches of science: we shall simply state what we believe to have been the results of their researches, with respect to the people and languages of Europe.

It has been inferred, chiefly from sepulchral remains, that at some very remote epoch the western parts of Europe were possessed by a people of a low degree of intellectual and social development, and it is supposed that they probably belonged to the same family of nations as the Iberians of Spain, or to a family, of which the Laps of Scandinavia are the modern representatives. The Iberians seem to have possessed, at one time, the whole of the Spanish peninsula, and even to have extended beyond the Pyrenees, far into France if not over the whole territory, and even into Italy and the islands of Corsica, Sardinia, and Sicily; but whether they belonged to the same family as the Laps, or were rather connected with the Berbers of Africa, is a point not yet, and perhaps not easily to be, determined. The Basques, who live in Biscay, Navarre, and the adjoining parts of France, and call themselves Euscaldunac, are believed to be the remains of this once great nation. At a very early epoch, which cannot be determined, these aboriginal races were intruded upon by people of the Gaelic, Celtic, or Keltic stock, who acquired possession of all France, Britain and Ireland, and subsequently penetrated into Spain, where they mingled with the Iberians, and produced the Celtiberians, and also into Italy, the northern part of which was called from them, Cisalpine Gaul, and so on to the head of the Adriatic Sea. Afterwards another people of kindred lineage, but speaking a language considerably different,

and known as the Cimbric, Kymraic, Cumbrians, or Cambrian race, acquired possession of the north of France, of all the southern parts of Britain, and of the eastern maritime Lowlands of Scotland, as far north at least as the river Spey, leaving the older Celts in possession of the north-western Highlands and Islands of Scotland and of all Ireland, and the southern and south-eastern parts of France. They seem likewise to have extended themselves along the German shores of the North Sea, as far as Jutland. The Iberians, the Kelts, and the Kymri, were the races that possessed the south-western countries of Europe at the dawn of history.

The north-east of Europe is the native seat of the Ugrian races, now best represented by the Finns; and people of this stock seem to have possessed the northern and north-eastern parts of Europe in the earliest times, extending from the shores of the Arctic Ocean and the White Sea, to the shores of the Euxine, and to have been the original Skuthians, whom we miscall Scythians; for though the name Cud, Scud, Czud, or Tschude, by which these people have been long known, and which is believed by Schaffarick to be the original of the Greek σκυθοι, is not a native name, but only applied to them by the Slavonians, yet the Sarmatians of old were themselves Slavonians, and the Greeks may have borrowed the name from them, and then in their ignorance applied it without distinction of races to all the people that lived to the north and east of the Black Sea. Jakob Grimm, however, prefers a Gothic etymology for *Skuthoi*, and supposes it to have been borrowed by the Greeks from the people of Thrace, who vaguely applied it to all the people farther north. At an early, but unknown epoch, Sarmatians, the ancestors of the modern Slavonic races, settled in the countries that lie to the north of the Black Sea, and seem to have pressed themselves gradually north-eastward upon the Ugrians, till they have nearly dispossessed them altogether of their country, while the Ugrians were pressed back in the same way from the south-east by Turkish and Tartar races. The modern Ugrian races are the Laps of Scandinavia, the Finns, and the Samoyeds and some other tribes of Russia, and the Majyars of Hungary.

Between the Sarmatians and the Skuthians of the east, and the Kelts and Kimbers of the west, the Gothic and Germanic races are found, at the dawn of history, pressing southward like a wedge; but where they came from, and how they found themselves on the shores of the Baltic at that epoch, it would be vain to inquire. They seem, however to have been very early divided into two great branches, one of which proceeded northwards to the conquest of Scandinavia, while the other directed their efforts southwards and westwards, till they became known to the Romans under the name of Germans. In the later times of the Roman empire, branches of this family were also in possession of Mœsia, and other countries to the north-west of the Black Sea, from which they have now entirely disappeared. From the northern branch of the Germanic race are descended the modern Swedes, Danes, Norwegians, and the natives of Iceland and the Faroe Islands; from the southern branch, the modern *Deutsch*, both high and low, or all the Deutsch inhabitants of Germany, Switzerland, France, and the Netherlands, and the English, and Lowland Scots, though the latter are indeed largely intermixed, with Gothic, Celtic, and Cambro-British blood.

The south-eastern peninsula of Europe is found possessed, at the earliest epoch, by races of unknown origin and lineage, who became in time the well-known Hellenes, or Greeks; and at an epoch at least as early, the neighbouring peninsula of Italy was possessed by races who seem to have gradually coalesced into *Latins* and *Romans*. With the conquests of the latter people, the Latin language was spread over Italy, France, and Spain, where it seems to have almost entirely superseded the aboriginal tongues, and laid the foundations of the modern languages of those countries. The Romans, after having brought all the nations of Italy, France, and Spain under subjection to their empire, were in their turn invaded and overthrown by the northern nations, various tribes of whom, under the names of Heruli, Ostro-Goths, Longobards, and others, penetrated into and settled in Italy; while Suevians and Visi-Goths settled in Spain, Franks and Burgundians in Gaul, Angles, Saxons, Jutes, and Frisians in Britain. In the first three of these countries, Italy, Spain, and France, so far were the invaders from extirpating the natives, that, on the contrary, they seem to have mixed freely with them, and to have rather adopted the languages they found prevailing than imposed their own. At this day indeed, the great bulk of the French people are believed to be of Keltic descent, and to retain the physical and mental characteristics of the Gauls, though most of them have entirely lost their ancestral language. In Britain the invaders seem to have preponderated over the natives, and entirely changed the language of the country, driving the unmixed natives into Wales, Cornwall, and Cumberland; and it is only in Wales that the Cambro-British language still lives. In the 11th century, England was invaded by a host of Normans and French; and from the gradual mixture of these with the Anglo-Saxons have been formed the modern English nation and language. Two or three centuries after settling in Spain, the Goths were dispossessed of that kingdom by Mohammedan invaders from Africa, a remnant of them taking refuge among the mountains of Asturias. In the course of seven centuries the descendants of these refugees recovered their lost possessions; and to have the blue blood of the Goths pure in his veins, is the proudest distinction of a Spaniard; so many of the nation being contaminated by the black (Moorish, not negro) blood of Africa. These pure Goths, however, are only the mixed descendants of Iberians, Celts, Carthaginians, Numidians, Romans, Suevians, Goths, and Vandals, from the last of whom the province of Andalusia (Vandalusia) takes its name.

The ancient inhabitants of the south-east of Europe are now represented by the Greeks, Albanians, and Wallachians. The Greeks not only occupy the new kingdom of Greece and the Ionian Islands, but are also spread over the provinces of Turkey and the adjoining parts of Russia and Austria. They have preserved the language and much of the character of the ancient Greeks. The Albanians, called also Arnauts and Skipetars, are believed to be the descendants of the ancient inhabitants of Albania, though mixed with Slavonic blood. The Wallachians, who possess Wallachia and Moldavia, and the adjoining parts of Hungary, Transylvania, and Bulgaria, and speaks a Roman language, are probably the descendants of the ancient Dacians, intermixed with a numerous Roman colony, which had been settled among them. Towards the end of the ninth century an Ugrian race settled in the ancient Pannonia, where they are now known by the names of Majyars in Hungary, and Szeklers in Transylvania.

The Tartars, who are spread over the south-eastern provinces of Russia, are believed to be the descendants of the Turkish portion of the armies of Zengis Khan, who invaded Europe in the thirteenth century, and whose successors domineered over the Muscovite Russians till the end of the fifteenth. In the sixteenth century they were dispossessed of their kingdoms of Kazan and Astrakhan, and subdued by the Muscovites, and their numbers are now very small in comparison with those of the ruling race. The Osmanli, or Ottoman Turks, a more important branch of the same family, first came into Europe in the fourteenth century, their third Sultan, Amurath, or Morad I., who reigned from 1358 to 1389, having then possessed himself of all Thrace, or Rumelia, and established his seat of government at Adrianople. In 1452, the Sultan Mohammed II. got pos

Europe. session by conquest of Constantinople, which has been ever since, not only the capital of Turkey, but also the metropolis of Islam, or the Mohammedan world. Since their great defeat at Vienna in 1683, the Turkish power has been declining, and to all appearance it will soon be swept out of Europe altogether. The Ottomans consider Asia Minor, or Anatolia, to be the home of their race, and seem quite prepared to cede Rumelia to whoever is able to take it. The Dobrudji (or Dobrudshee) Turks, a numerous tribe distinct from the Osmanli, possess the north-eastern corner of Bulgaria, between Shumla, the Danube, and the Black Sea. The total number of Mussulmans in European Turkey is estimated at about four and a half millions; but of the Ottoman Turks themselves the number is variously estimated between 700,000 and 2,100,000. The Turks seem to have come originally from Central Asia, and to have been of the Mongolian or yellow race of mankind. They seem, however, to have mingled freely with all the western nations among whom their conquests carried them, and from the intermixture has sprung a race who are but little different from natives of Caucasian origin. Some ethnographers, in consequence, believe them to have been even originally Caucasian; but it is certain that many Turks, even in Europe, still exhibit the strongest Mongolian forms and features, and that phenomenon seems to us to indicate that these are pure Turks, of the original stock, while their Caucasian brethren are of mixed descent.

With respect to physical characteristics, it may be said generally that the nations of the south-west and south, as French, Italian, Spaniards, Greeks, are melanous, or dark-complexioned, while the Gothic and German races are generally xanthous, or fair-complexioned, with blue or gray eyes, and fair hair. The former are lively and energetic, more imaginative and inventive than the northern races, but less persevering, and the more southern portions of them, indeed, fonder of idleness than of work. They are likewise more temperate in eating and drinking than the northerns, but more passionate and vindictive. The northerns, on the other hand, though less imaginative and inventive, are more thoughtful, serious, and persevering, and more addicted to pursuits that exercise the understanding than to those that merely amuse the fancy; but they are less temperate in eating and drinking, which may be ascribed to the influence of the colder climates under which they live. The Slavonic, Turkish, and Tartar races are all melanous, or dark, and, as compared with the western nations, still in a lower degree of civilization, and intellectual and industrial development. "In regard to physical form," says Dr Latham, "the Ugrians are light-haired rather than dark, many of them are red haired." Scheffer, however, in his *History of Lapland*, says, that though young women are indifferently handsome and of a clear skin, most of the men are swarthy, and the hair of both sexes is generally black and hard, very seldom yellow. Professor Berghaus says, that the skin of the Laps is yellow-brown, and they have brown hair and brown eyes; and that the hair of the Finns is sometimes black, sometimes blond, yellow-brown, or red, the face dirty brown, and the eyes gray.

Languages. Europe contains, in proportion to its area, a greater number of distinct and strikingly marked families of languages than any of the other quarters of the world. A careful division gives at least ten independent groups, though, in respect of language as well as geography, Europe forms, with a slight exception, only one great whole with western Asia. The greater number of its languages consist of members of the Indo-European family; a small proportion belongs to the Shemitic family; branches of various Tataric or Tartaric languages, spread from Asia into the very heart of Europe; in the north of Russia and Scandinavia various branches of the Finnish language are still spoken, and one branch—the Majyar—is found isolated in the centre of the continent. The Basque, solitary, and of unknown origin, still lingers among the western Pyrenees; a small remnant of a language, which is presumed to have been once spoken all over the Peninsula. A remarkable characteristic, however, of the European languages, is the fact that their linguistic connection is not supported by the physical family likeness of those who speak them; or, in other words, that nations of the same race do not always speak the same language, while, on the other hand, branches of the same language are spoken by people of different races; language being more changeable than physiological character. There is indeed abundant evidence to show that the principal physical characters of a people may be preserved through a long series of ages, in despite of climate, mixture of races, invasions of foreigners, progress of civilization, or other known influences; and that a type can long outlive the language, history, religion, customs, and recollections of those on whom it is impressed.

Of monosyllabic languages, such as the Chinese, there are none in Europe. Of the higher class, called agglutinizing languages, which express the idea itself by a fixed word, and its relations by letters or syllables loosely and mechanically joined with it, Europe furnishes examples in the Tartaric, Caucasian, and Majyar languages. The Tartaric languages form a continuous chain from the east of Asia to the centre of Europe, and exhibit in their numerous branches the remarkable peculiarity of improving steadily and regularly as they proceed westward. According to traditions current among the tribes that speak them, their first home must be sought for on the high table-lands of the Altai; and hence the name of *Altaic*, by which they are frequently designated in modern writings. The whole Tartaric family consists of two principal and essentially different branches; the Tartaric Proper in the east, consisting of the Tungusian, of which the Mantchoo is a variety, the Mongolian, and the Turkish; the European branch, in the west, comprehending the numerous branches of the Finnic, or, as the Slavonic races call it, the Tschudic. Only the Tungusian is not represented in Europe; all the others are found somewhere or other. The *Mongolian* appears in the Olot dialect spoken by the numerous Mongolian hordes that occupy the vast plains to the east and north of the Volga; and a small separated colony at the confluence of that river with the Samara. The Turkish is spoken in a comparatively small portion of Europe by a few millions of the Osmanli or Ottoman Turks in European Turkey, and several scattered tribes. Only the common people, however, in Turkey speak pure Turkish. The language of the more refined classes is filled with Arabic and Persian elements; and the more refined the language the more foreign elements it contains. Various dialects of the same language, but not essentially different from that of Turkey, are spoken by the Tartars of Russia. Those who dwell in the south, in the neighbourhood of the Caucasus, are called *Tartars;* to the west of the Ossetes, and on both sides of the Elburz, they appear as *Karatschai;* more numerous and powerful near the mouths of the Danube, as far as the Dneister, through the Crimea, and along the north side of the sea of Azof to Taganrog, and then again north of the Caucasus till they meet the Olot on the Volga, as *Nogai*; north and west of the Caspian Sea, and along the Ural river, as *Kirghiz;* then as *Tartars of Kasan;* then as the *Bashkirs*, in the valley of the Ural, mingled in the governments of Orenburg and Perm with the *Meshtscheryakes;* and finally, the tribes who speak the *Tshuwassian* dialect. Only the language of Kasan is, properly speaking, a written language.

Tartaric.

The Finnish family of languages, closely connected with each other by striking analogies, and best represented in its most perfect form, the Finnish proper, is sometimes called *Uralian*, or *Ugrian*, from the geographical situation of some important tribes, or Cudic, Scudic, Tzudic, Czudic,

or *Tschudic*,[1] from the name applied by the Slavonic Russians to all the Finnish tribes of the empire. Some of these dialects are spoken in the whole range of country along the Ural, by Samoyeds and Ostiakes, and are as yet but little known, some of the tribes being not even converted to Christianity. It has been, however, so far satisfactorily established that they are the parent stock from which is derived the now entirely disconnected Majyar. Their western neighbours are the Syryaenes, Permians, and Votyakes, whose languages differ slightly from the others, though they are not free from Russian and Tartaric mixture. The Tsheremisses and the Morduines are separated colonies of the same race on the banks of the Volga, and are commonly distinguished as the Bulgarian branch of the Finnish family. The literature of all these eastern dialects is almost entirely limited to translations of parts of the Bible. Of greater importance are the western dialects, **Lappic.** the *Lappic*, the *Finnish* proper, and the *Esthic*. The first extends from the White Sea and the Northern Ocean, over the northern parts of the Scandinavian peninsula, down to 60° N. Lat. The Finnish Proper, called by the Finns themselves *Suomi*, prevails in Finland, and the Esthic, in Esthonia, the northern part of Livonia, and the adjacent islands. These three languages have each several minor dialects, but they are all closely connected with each other. Quite cut off from their cognate races, surrounded by Slavonians and Wallachians, and mixed with Germans, Gypsies, Armenians, and Jews, **Majyar.** we find the Majyars in Hungary, who speak a language connected with the Finnish. It is not free from foreign elements; but in respect of structure and grammar, it is one of the most developed of all the Tartaric languages. It is mainly the same wherever it is spoken; but it is found pure only among the Cumanes, Jazyges, and Haiduks. A large Majyar population fills the western part of Hungary; those in the east, in Transylvania, are called *Szekler*. The name of their country indicates the race they belong to, *Hungary* being derived from their name Ugri, passing through the dialectic changes of Ungri, Hungri, and Hungari.

Caucasian. To the agglutinizing family likewise belong the languages of various tribes of the Caucasus, and the Basque in the Pyrenees. The former, the Caucasian languages, are as **Basque.** yet very imperfectly known to philologists. The Basque, a small but highly interesting relic of a once powerful family, still lives in a small strip of country at the innermost corner of the Bay of Biscay, along the French and Spanish frontiers, and some distance westward along the coast of Spain. The people who speak it call it the *Euscara*, and themselves *Euscaldunac*. It is divided into three dialects, not essentially different from each other, but entirely different from all the other languages of Europe, to none of which the Euscara shows any relation.

Shemitic family. The essential difference between the agglutinizing and the inflecting languages, is the power which the latter possess of representing the connection of idea and relation in the mind by a corresponding radical and inseparable connection of the two elements in the same word. Two great classes of languages constitute the great body of inflecting speech, namely the Shemitic and the Indo-European; but the former is now represented in Europe only by a single dialect, the *Maltese*, which was formerly considered to be a relic of the Phœnician, or old Punic, but is now more generally considered to belong to the Arabic stock. It is spoken in the island of Malta by the native inhabitants.

Indo-European. The rest of the languages of Europe belong to the great Indo-European family, which may be arranged into the *Arian*, *Pelasgic*, *Slavic*, *Celtic*, and *Germanic* groups, each of which has, or has had, some representative in Europe, though of very unequal extent and importance. The Arian group is almost confined to Asia, its chief representative in Europe being the humble and long despised dialect of the **Gypsy.** *Gypsies*, which that race have tenaciously preserved through centuries of the most lawless and most vagrant course of life. Though mixed with the words and elements of various other languages, especially Slavonic and Romanic, the various dialects spoken by the Gypsies in different parts of the world are essentially the same, and their descent can be satisfactorily traced back to a connection with the great Arian tongues of south-western Asia, and especially, in spite of degeneration and mixture, with the Sanscrit of India itself. **Armenian.** The *Armenian* is properly only an Asiatic language, but it is spoken in Europe by many thousands of Armenians, who, like the Gypsies, are scattered over south-eastern Europe, in various detached colonies. Though much changed in form and structure from the original Iranic, of which it seems to have been a branch, it still retains enough of the family likeness to connect it with the Arian group. The original character, however, of the old Iranic or Persian languages is most purely preserved and best represented in the Ossetic, the language of a small tribe on the very **Ossetic.** confines of Europe. The Ossetes dwell in the heart of the Caucasus, surrounded by alien races. History knows nothing about them; but their language shows at once their origin and connections. They call themselves by the old family name of *Iron*; and their language is almost identical in its grammar and words with the older dialects, and even a better representative of the Zend and the old Persian than the modern language of Iran or Persia itself.

Greek and Latin. Greek and Latin are the two languages that form the bases of the Pelasgic group of modern European tongues. At a period anterior to the dawn of history, the Greek in its oldest, and the Latin in its earliest form, are believed to have very closely resembled each other. The Latin generally bears the stamp of higher antiquity than the classic Greek, and resembles the Æolic more than the later dialects of the Hellenic tongue. Be that as it may, however, the Greek is now represented in Europe by the Romaic, or modern Greek language, which, in its present form, has more resemblance to the ancient Greek than any of the modern Latin languages have to the ancient Latin. It is spoken in the islands of the Archipelago, and of the western coast of Greece up to Corfu, in the Morea, and in Hellas Proper, and Rumelia, though interspersed with Turkish colonies, eastward to Constantinople. Near Taganrog, on the Sea of Azof, there is a small colony, and further south, on the western shore of that sea, there is a larger settlement of Greeks, surrounded by Slaves and Tartars. Greeks are settled also in all the towns of the Crimea, and along the shores of the Black Sea. But the *Hellenic*, or literary language of the modern Greeks, having been of late highly cultivated on the model of the ancient classic language, now differs very considerably from the vulgar Romaic. **Albanian.** The Albanian language has been commonly considered to be a descendant of the ancient Illyrian; but the presumption is now generally in favour of its descent from the same original stock as the Greek, from which, however, it must have been separated at a very early epoch, the forms which it has in common with the Greek more nearly resembling the oldest than any of the latest forms of that language. It is spoken by about a million and a half of people, who call themselves Schkipetars, while the Turks call them Arnauts. They live in Albania and those parts of Greece that lie immediately to the south of it, and extend eastward, with frequent interruptions, far into Bulgaria.

Latin branch. Latin, the language of the all-conquering Romans, was

[1] The first letter of this name is the Slavonic C, the sound of which cannot be properly represented by any combination of Roman letters. It is usually represented by Cz or Tz, as in Czar or Tzar, Priepecz or Priepetz, Galacz or Galatz, Czud or Tzud, or Tshoude.

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extended with their empire over the countries of south-western Europe, where it has left noble descendants in the French, Spanish, Portuguese, Romance or Provençal, and Italian languages. Of these the bulk of the words are substantially Latin, but the forms or inflexions and grammatical structure have been very much changed, though nowhere entirely destroyed. They have been largely mixed with words from other languages of the Gothic, Germanic, and Celtic stocks, and in Spain, from the Basque and Arabic also. As might have been expected, the Latin has remained purest in Italy, where not one-tenth, it is thought, of radical words is foreign. In Spanish, little more than the half of the radicals is Latin, but it has retained more of the Latin inflection than even the Italian. The Portuguese, originally only a provincial dialect of Spanish, still remains almost identical with it in respect of words and structure, but differs in respect of certain Spanish sounds, to which the Portuguese seems to have a national antipathy. The Provençal forms a sort of linguistic as well as geographical transition from those languages that have preserved most of the Latin, to the French, which is furthest removed from it. It is spoken in the south of France, where it is distinguished from French as the *langue d'oc*, while French is called the *langue d'oui*—the one using *oc*, the other *oui*, for the affirmative particle *yes*. It was formerly spoken more generally and more widely than at present, extending even beyond the Alps and the Pyrenees into Italy, Switzerland, and Spain. The French rose upon the ruins of the Provençal, and has now become the general, or, at least, the literary and official, language of the great French nation, and also of the Belgians, nearly a half of whom are Walloons, a people who speak a dialect of the French. All these five languages, however—Italian, French, Provençal, Spanish, and Portuguese—are divided into multitudes of provincial dialects, which ages of education will hardly suffice to destroy. Besides these noble branches of the old stem, there are two smaller branches isolated in Europe—The *Wallachian* and the *Rhæto-Romanic*. The former is spoken in Wallachia and Moldavia, in several dialects, by a people who call themselves *Romeni* or *Romenia*, a name by which they have been long known. Their language shows in its essential features a convincing relation to the Latin, although the words are, to a great extent, of foreign origin—a circumstance easily explained by their position, entirely cut off from Roman or Italian influence, and surrounded by races speaking entirely different languages. The most of the words are now Slavonic, Majyar, Turkish, Greek, or German; but there is enough left of pure Latin in the words, and still more in the structure and inflection, to establish beyond doubt its direct and immediate descent from the Latin. It was probably introduced in these countries by a Roman colony. The Rhæto-Romanic is the language of the canton of the Grisons in Switzerland, a portion of the ancient Rhætia. It is a much-mixed and neglected language, now bearing an essentially German character, grafted on its old Latin stock.

Slavonic.

The great Slavonic race which now occupies the eastern half of Europe, and threatens to extend its dominion over all the Continent, did not at first appear under that name in European history. By the ancient writers of Greece and Rome they were called *Sauromats* or *Sarmatians*, a name resembling in sound, and radically identical with, the name which the Slavonians now give themselves—viz., *Serbs*, *Sorabians*, or *Servians*. Their German neighbours call them *Wendes* or *Winds* (*Vendes* or *Vinds*). From the banks of the Dwina, in the north-east of Russia, to the Bohemian Erzgebirge in the west, and the Black Sea, the Adriatic, and the Archipelago in the south, some branch or other of the Slavic is spoken. The name *Slave* is derived by themselves from the word *Slava*, glory, and is a designation peculiarly gratifying to their national pride. Modern Slavonic scholars divide the great bulk of the Slavic languages into two branches—the western and the south-eastern; others simply into the eastern and the western. The south-eastern or eastern division contains the Russian, Bulgarian, and Illyrian languages; the western contains the Leckian or Polish, the Czech or Bohemian, the Sorabian, and the Polabian, the last of which is now extinct.

Russian.

The Russian extends over the greater part of the immense territory of European Russia, and reaches in the south, in a compact mass, through eastern Gallicia, into Hungary. Russian colonies are frequent among the Tartars and Finns of the Urals, and a narrow but compact band of Russians follows the course of the Volga, between Kalmucks and Tartars, down to the Caspian Sea, and up again in a line parallel to the Caucasus, until they meet the Russian population at the Sea of Azof. From the Polish, it is separated with tolerable accuracy by the political boundary line of Poland. It is spoken by upwards of thirty (Schafarick says thirty-eight) millions of people, and is considered to be one of the sweetest and pleasantest of the Slavic tongues. It is divided into three dialects—the Great Russian, the Malo-Russian of the south, and the White Russian in the west, each of these again being sub-divided into numerous smaller dialects. They are all united, however, by a common written language, the dialect of Moscow, an inferior branch of the Russian, much mixed with foreign elements, but spoken over all the central and northern part of Russia. The Malo-Russian is spoken in the south, beginning with Gallicia, and goes north of the Sea of Azof, even beyond the boundaries of the Russian proper. The Rusniaks or Ruthenians, in Red Russia, the Bukovine, Galicia, and the north-eastern part of Hungary, speak a variety of the Malo-Russian. In the south of Poland also, and in various parts of Wallachia and Moldavia, detached tribes of this nation are found. The Kozaks also, except those of the Don, who are more Russian, belong to the same race, which amounts altogether to more than 13,000,000 of people. The White Russian occupies a much smaller extent of country. It is spoken in Lithuania, a portion of White Russia, and Volhynia, and extends even to the south of the river Priepecz. Its peculiarities are mostly the same as those of the Malo-Russian; and what distinguishes it mostly from the other dialects is the very large admixture of Polish elements.

Bulgarian.

The Bulgarian is supposed to have been formerly spoken over the countries that formed the Bulgarian empire, extending up the Danube into Hungary as far as the Carpathian Mountains and the sources of the Theiss. The modern Bulgarian is now almost confined to the province of Bulgaria, to the south and east of the Danube, which, however, it crosses at its mouth, to follow the west bank of the Pruth. The Bulgarian is very unlike most of the Slavic languages, and has been largely intermixed with foreign elements of all the surrounding languages. The church Slavic, which has been considered the mother of all the living Slavonic tongues, seems to have been nothing more than one of many Slavic dialects, earlier developed and more cultivated than the rest; and historical evidence shows that this church, or old Slavic, the language of the great Slavic apostles, Cyril and Methodius, who flourished in the ninth century, was the old Bulgarian we have mentioned. Whatever it may have once been, the church Slavic is no longer a national tongue, but it remains as the common literary language of all the Slavic nations who belong to the Greek Church, the Russians, Bulgarians, and Vindes. During the middle ages it exercised a permanent influence on the style of authors, and, through them, on the language of the whole race; and it still speaks to them daily and hourly through the Bible and their books of ritual, though it is said that even many of the priests in Russia do not understand the sacred language of their official duties.

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Illyrian.

The Illyrian comprises, as a collective name, the Servian, Croatian, and Slovensi, three cognate dialects, forming one language, and occupying the north-western portion of the Turkish, and the adjoining parts of the Austrian, empires. Majyars and Germans meet it in the north and west; in the south it is bounded by the Adriatic; and on the east by a line drawn between Widdin and Temesvar. The Servian is spoken by more than a million of Servians, who live between the Danube and the Balkans. A large number of Servians likewise live in Hungary. It is subdivided into three distinct dialects, which extend into the provinces of of Herzegovina, Bosnia, Montenegro or Upper Albania, Dalmatia, Croatia, Syrmia, Slavonia, Banat, Central Hungary, and Servia. The Croatian, or Chorwatian, is spoken in the eastern portion of the linguistic territory occupied by the Illyrian. It mostly prevails in the districts of Agram, Kreus, and Warasdin. It is subdivided into two minor dialects. The Slovensi, or Vindish, is spoken principally in Styria, Carinthia, and Carniola, in the western part of Hungary, along the rivers Muhr and Raab, and in parts of Illyria and Istria. The people of these districts, amounting to more than a million, call themselves Slovensi, but are better known abroad as Vindes, a name that was formerly given by the Germans to all the Slavic nations.

Polish, &c.

Of the western branch of the Slavic languages the Leckian or Polish was once one of the most extended branches of the Slavic family, being spoken even by those tribes on both sides of the Oder that are now almost entirely Germanized, in Pomerania, the Mark, and Silesia. At present it occupies, in two dialects, only the country that is now inhabited by Poles. This includes, besides Poland proper, the adjoining part of western Russia, the Duchy of Posen, Cracow, Galicia, and Ludomiria, a small portion of Silesia, and the isolated colony of the Kassubes, on the coast of the Baltic, in Pomerania, containing altogether about ten millions of people. The Leckian has its name from the Lekhes, a tribe of unknown origin, but which yielded in the tenth century to that of the Poles.

Czekh.

The Czekh is the language of the Slavic inhabitants of Bohemia, Moravia, and north-western Hungary, besides a number of isolated settlements throughout the latter country of people usually called Slovaks. They amount altogether to about six millions. The Czekh, however, is not exclusively the language of Bohemia; for all around the frontier, and especially in the west, German largely prevails. The Moravian and Slovak branches of the Czekh are divided into numerous dialects.

Sorabian.

The Sorabian, or Vendish, once extending from the Baltic to Bohemia, and from the frontiers of Poland to the Elbe and the Saale, is now spoken by so few people that it is sometimes said to be extinct. It is still spoken, however, in some parts of Lusatia and Brandenburg. These Vindes are the descendants of a Slavic race that settled early in the very heart of Germany. They now amount to scarcely two hundred thousand people, and speak the two dialects of Upper and Lower Lusatia, which are again much subdivided, and contain a large admixture of German. These Vindes appear in history as Weteli or Wiltzi in Pomerania, as Obotrites in Mecklenburg, as Wagrians, Drewanians, &c. The language of the last-named tribe is still spoken by a few survivors of this ancient race. Protected by almost impassable marshes, and living in barren, sandy plains, they have long withstood the effects of time and invasion.

Connected with the Slavic family is the Lettic, subdivided into the Lithuanian, the Prussian, and the Lettic proper. The Lithuanian has alone preserved the characteristic seven cases and the dual of the Indo-European languages, and among the former some are so well preserved as to be even identically the same as those of the Sanscrit. It is especially important for the understanding of the cognate languages, especially the Slavic, being, as it were, the connecting-link between the latter and the other Indo-European languages. It is, however, now in use only among the common people of some portions of East Prussia, around the towns of Memel, Tilsit, Ragnit, Labiau, and Insterburg, and their eastern frontiers, to the number of about 200,000; and Schaffarik counts about 1,282,000 people of the same race in Russia. The Prussian language has become entirely extinct. It was spoken along the shores of the Baltic, between the Vistula and the Niemen, by about two millions of people, but has yielded to German intrusion. The Lettic proper is the popular language of Courland, the greater part of Livonia, and of the peninsula that separates the Curische Sea from the Baltic. It stands very nearly in the same relation to the Lithuanian as that of the Italian to the Latin, being a modernized dialect of the older tongue.

Germanic languages.

The Germanic class of Indo-European languages includes not only the German proper, or Deutsch, but also the languages of Sweden, Denmark, Norway, Iceland, and of those ancient nations known to the Romans as the Goths, and of the Anglo-Saxons, and their descendants the modern English and Lowland Scots. The Gothic is the oldest known of all the Germanic languages, and its oldest form, known to us by the fragments of the translation of the Bible made by their bishop, Ulphilas, who died A.D. 388, is the Mœso-Gothic, which was the language of the Goths who then dwelt in Mœsia (the modern Bulgaria and Servia). The next oldest form of the Gothic is the old Norse of Iceland, where, owing to its isolation, it has been preserved free from mixture and change. It is the basis of the modern languages of Norway, Denmark, and the Faroe Islands. Swedish and Danish, which belong to the same family, have suffered in proportion as they have come more into contact with the nations of the Continent. They contain many foreign elements, and the Danish especially has lost most of its original force and originality, chiefly through the influence of the German. Of the same kindred was the Anglo-Saxon, which has now been superseded in Britain by the modern English, which, though still retaining much of its Gothic patrimony, has lost almost all its inflections, and shows a strong tendency to return to the primeval monosyllabic form. It presents probably a greater and more recent mixture of various elements derived from all languages than any other in Europe, or perhaps in the world. The Anglo-Saxon has likewise disappeared from its ancient continental seat, though traces of its older forms may still be found in the low German dialects. Its nearest cognate, the *Frisian*, was one spoken all over the vast territory that extends along the northern shores of Germany between the Rhine and the Elbe, and to the north of the latter. It has ceased to be a national tongue, and to be used for literary purposes, but still lives as the popular language in all that region, and is preserved in great purity in West Friesland. The remaining languages which belong to the older or Gothic branch of the Germanic tongues may be called the low German, a name now limited to the Neder-Duitsch, which is the language of the Netherlands, and to the low German proper, so far as not spoken in Holland and Belgium. The Neder-Duitsch contains two principal dialects, the Dutch and the Flemish, the former holding its part of the Netherlands to the exclusion of every other language, the other struggling against the increasing power of the French. Dutch and Flemish are essentially the same language, the difference extending hardly beyond the different manners of writing them. The popular language of the countries between the Rhine and the Weser, and the Weser and the Elbe, where it is not Dutch or Frisian, is the Platt-Deutsch, which, though differing essentially from the Anglo-Saxon, closely approaches the Neder-Duitsch. It is softer and more flowing than the Ober-Deutsch, or high German, and delights in pure full vowels. It is spoken all along the northern coasts of Germany, Prussia, Courland,

and Livonia, and even far into the interior of these provinces.

High German, or what is called pre-eminently, the German language, prevails in the central and southern parts of Germany, and a cultivated dialect of it is the literary and official language of the whole country. As a separate language it is supposed to be as old at least as the Gothic, and is now considered as being divided into three principal dialects, the Suabian, the Bavaro-Austrian, and the Frankish. It has preserved more of the ancient grammar and inflection than the English, Dutch, or Danish; but, having lost many full and pure vowels, it is far inferior in that respect to the full-sounding, euphonious Swedish. It is spoken not only in Germany but also in the north-eastern parts of Switzerland, and in parts of Hungary and Transylvania, Sleswig and South Jutland, and to the east, mixed with low German, beyond the limits of Courland. Westward it extends beyond the Rhine into France, where the meeting of the French and German dialects may be traced very nearly by a line, drawn from the North Sea, between Gravelines and Calais to the vicinity of Aix-la-Chapelle, having Gravelines, Hasebrouk, Yprès, Courtray, Brussels, Tirlemont, Tongres, Maestricht, and Eupen to the north; and St Omer, Lille, Tournay, Nivelle, Waterloo, Jodoigne, Warem, Liege, and Limburg to the south. There, turning southwards, the line passes to the east of Malmedy and the west of Arlon. Entering France a little to the east of Longwy, and crossing the Moselle between Metz and Thionville, it follows the watershed between the Moselle and the Saar, and the crest of the Vosges to the Ballon d'Alsace, and thence passing to the north of Belfort, it crosses the Swiss frontier within twenty miles west of Basel. Through Switzerland the line crosses the Birse below Delsperg or Delemont, passes south-west by Bienne, Erlach, Morat or Murten, and Freiburg or Fribourg, where one half of the town speaks German and the other French, thence southward along the border of Vaud and Bern to the sources of the Saane, then follows the line of the Alps, to the Gemmi mountain, whence it crosses the Valais to Mont Rosa. About two-thirds of the Swiss are Germans.

Celtic.

For a long time the Celtic was considered to be a language that had no connection with any branch of the Indo-European family. It has now, however, been shown and generally admitted to be a branch of the family that must have been separated from the other branches at a very remote epoch. It is the language that has reached the farthest west in Europe; but is now confined to the remotest corners of Great Britain, Ireland, and France, where it maintains a precarious existence against the inroads of the national languages of these countries. It seems to have been once extensively spoken in Western Europe, occupying not only the British islands and France, but also the western and northern parts of Germany, Switzerland, northern Italy, and the countries even farther east round the head of the Adriatic. Celtic elements can even be traced in Greek, and still more certainly in Latin. At present there are four Celtic dialects, or varieties still spoken: the Gaelic, or Erse, in the Highlands and western islands of Scotland; the Irish in the south-western and western parts of Ireland; the Welsh in Wales and the adjoining borders of England; and the Armorian, or Breyzad, or Bas-Breton, in the departments of Finistere, Cotes du Nord, Morbihan, Ille and Vilaine, and Lower Loire, in France. The Erse of Scotland and the Irish are so nearly related that the more intelligent speakers of either can understand the other. They differ, however, very greatly from the Welsh and the Bas-Breton, which are distinguished as Cymric, and are probably less pure and unchanged than the Erse and Irish. The Manx language, spoken in the Isle of Man, in the Irish Sea, is a very impure Celtic dialect.

The numbers of people who speak these diverse languages cannot be precisely ascertained; the following statement, however, may be considered as an approximation at least to the relative proportions. The numbers of the Slavonians are those given by Schaffarick, dating so far back as 1826. but probably nearer the truth now than they were then, though even yet in some respects considerably exaggerated. The total number exceeds that of our general table, and the excess, we believe, lies principally in the Slavonian portion; the number assigned by Schaffarick to Austria exceeding the number given in the Gotha Almanac of the present year by 1,509,804.

I. German and Gothic.		
High and Low Deutsch or Germans	42,821,000	
Nieder-Duitch, and Flemings of Holland and Belgium	5,703,000	
Danes, Swedes, Norwegians	6,534,000	
		55,058,000
II. Latin.		
French, Provençal, and Walloon	37,243,000	
Spanish and Portuguese	17,053,000	
Italian	23,544,820	
Vallachian	3,000,000	
		80,840,820
III. English		27,625,862
IV. Slavonian.		
Muscovites, or Great Russians	35,314,000	
Malo or Little Russians and Ruthenians	10,370,000	
White Russians	2,726,000	
Bulgarians	3,587,000	
Servians and Illyrians	5,294,000	
Croats	801,000	
Carinthians	1,151,000	
Poles	9,365,000	
Bohemians and Moravians	4,414,000	
Slovacks, in Hungary	2,753,000	
Wends, in Lusatia	142,000	
		78,691,000
V. Letts and Lithuanians		1,588,993
VI. Finns, Laps, and other Ugrian races in Sweden, Norway, and Russia	3,519,620	
Majyars and Szeklers	6,000,000	
		9,519,620
VII. Turks and Tartars		3,500,000
VIII. Greeks and Albanians		2,500,000
IX. Basques or Euscaldunacs		650,000
X. Maltese		120,000
		260,094,295

We have not distinguished the Celts, Jews, Gypsies, and Armenians, because we have no means of ascertaining their respective numbers; and because, though they have all peculiar languages of their own, which they speak among themselves, yet they generally speak the languages of the countries in which they live, and are counted, as such, in the general amount of population. The Jews, however, in Europe are reckoned about 2,228,000.

Number of inhabitants.

The number of the inhabitants of Europe has been progressively increasing, slowly in the early part of the century, but more rapidly as we approach the present times. This is owing doubtless in a great degree to the long prevalence of a general peace; and, though, for the last 30 years or more, and especially within the last ten, emigration has been going on to an unprecedented extent, yet in many parts of Europe population is pressing too rapidly on the means of subsistence and employment, and would almost seem to require another general war, like that of the French revolution, to effect another clearance. It would however be quite out of place here to attempt to discuss the principles of population, sanitary improvement, and social progress, and the means of obviating the evils that arise from the ignorance and the barbarism that still prevail too largely among the masses of the people in all the countries of Europe, not excepting even the most favoured: we shall

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therefore content ourselves with stating here the numbers of the people of Europe at different periods, referring our readers to other articles for more minute information on the subjects we have hinted at.

The number in 1787 is said to have been.....	144,000,000
" at the peace of 1815...............	180,000,000
" in 1833, according to Balbi......	227,000,000
" in 1854, according to our table,	258,778,856

The first three of these enumerations we believe to have been in a great degree conjectural; and indeed it has been only within a comparatively recent period that measures have been taken by the governments of Europe to ascertain precisely the amount of the population of their respective countries. Even yet, in some of them, as in Spain and Turkey, the census is little better than a rough guess; and even when most correctly taken it is only an approximation to the truth; for we cannot get a general census of the whole of Europe taken on the same day, or even in the same year. Neither have we attempted to give the average number of inhabitants to each square mile, or what is called the relative population; because it seems to us that such averages are utterly futile, and worse than useless, unless the countries compared were entirely alike in the configuration of the ground, the quality of the soil, and the nature of the climate; in a word, possessed in every respect of the same natural qualities and advantages, and subject to the same social arrangements.

Religions.

With the trifling exception of a comparatively few Mohammedans, Jews, and heathens, the nations of Europe are professors of Christianity, and Europe collectively is distinguished from the realms of Islam by the title of Christendom. These professors, however, are divided into three great classes or churches, which not only hold no intercommunion, but are deadly rivals, conceiving it to be their duty to labour for the conversion at least, if not always avowedly for the extirpation, of each other. These are the Roman Catholic and the Protestant churches in Western Europe, and the Orthodox Greek church which domineers over the eastern half of the Continent. In the Roman Catholic and the Greek churches no differences of opinion, and consequently no sects, are permitted; but the Protestant church is divided into a multitude of rival sects, distinguished from each other by every variety of opinion respecting doctrine and discipline, and forms of worship. Some of these sects have been constituted into established national churches; but even these have been compelled, by the spirit of the age and the force of circumstances, to become tolerant, though the *odium theologicum* still occasionally shows itself, with all its proverbial bitterness.

The Roman Catholic or Latin church acknowledges the Pope or bishop of Rome as its spiritual sovereign, and the clergy are still numerous and wealthy. This church includes within its pale France, Belgium, Poland, Italy, Spain, and Portugal, and the greater part of the people of Ireland, and of the Austrian empire, about a half of the Prussians, Swiss, and Germans, and considerable numbers in Great Britain and the Netherlands.

The Greek church does not acknowledge the Pope; and though the Patriarch of Constantinople claims, as he once enjoyed, the same spiritual supremacy, his authority is now restricted to the limits of the Ottoman empire. The dominion of the church, indeed, extends over all the eastern half of Europe, including the Christian subjects of Russia, Turkey, and Greece, and a considerable number in Austria; but the Russians are subject to the authority of the Holy Synod of the Russian empire, of which the Czar is the spiritual as well as the temporal head; and in the new kingdom of Greece a similar Holy Synod has been constituted, with the king for its head. In Russia, dissent from the doctrines of the church is barely tolerated, yet there are within its limits various sectaries, all comprehended under the general name of *Raskolniks*, and frequently subjected to treatment little short of persecution.

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The principal sectaries of the Protestant church are distinguished as Lutherans, Calvinists, and Arminians. Lutheranism prevails in Prussia, Sweden, Denmark, Norway, Hanover, Saxony, Wirtemberg, and some others of the smaller German states, and in the Baltic provinces of Russia. It reckons also many members in Hungary and other provinces of Austria. The Lutherans do not absolutely condemn a hierarchy, but they do not admit the divine institution of the order of bishops. Their bishops therefore are generally no more than the name implies, mere superintendents or inspectors of their respective dioceses. Their prelates are in all cases subject to the political sovereigns of the respective states, who are recognised as heads of the church. In Sweden, however, the Lutheran prelates form one of the four orders of the legislature. In Denmark, Norway, and Iceland, they have no prerogatives that can give them political influence. In the Calvinistic churches the government is strictly republican, and they reject any other headship than that of Christ. Calvinism prevails in England, Scotland, Holland, the Swiss cantons of Bern, Basel, Zurich, Vaud, and Geneva, the Duchy of Nassau, the principalities of Electoral Hesse, Anhalt, and Lippe, in Germany, the departments of the Gard, Ardeche, Drôme, Lot-et-Garonne, and others in France, Hungary, Transylvania, and the military borders of Austria; and Calvinists are also numerous in Prussia. In Scotland and Holland the national churches are Calvinistic. In Great Britain generally the Calvinists are divided into two great classes, *Presbyterians* and *Congregationalists*, the former being governed in spiritual matters by local, provincial, and general councils, called kirk-sessions, presbyteries, synods, and general assemblies; in the latter, each congregation assuming the full status of a church, and exercising supreme ecclesiastical authority over its members. There is, however, substantially, little difference between the two classes in this respect; for the Presbyterians claim and exercise the right of seceding and constituting new churches as often as occasion requires, so that even in the pre-eminently Presbyterian Scotland (to say nothing at present of England and Ireland, and America) there have been existing at one time so many as six or seven separate and jealously rival Presbyterian churches; and there has been found no practical limit to the increase of their number by secession or disruption, so that even one minister and his congregation may legitimately constitute themselves into a Presbyterian church. Calvinists arrogate to themselves and their doctrines exclusively the titles of *Evangelical* and *Orthodox*.

The *Arminians* are opposed to Calvinists in respect of five points of doctrine, zealously held fast by the latter; and Arminian doctrine is now very prevalent among Protestants, especially in Holland and England, but Arminians nowhere form distinct acknowledged churches.

The name of *Episcopalians* is given to a numerous body of Protestants, who, in addition to the leading doctrines of Protestantism, maintain the divine origin and institution of episcopacy, and the unbroken transmission from the apostles of the "holy orders" of the clergy. To this class belongs the Established Church of England and Ireland, whose doctrines are contained in 39 articles, sanctioned by act of parliament, and which are understood to have been a compromise between conflicting opinions, so that all might be brought within the pale of the church. In its forms of worship this church has retained so much of the Romish liturgy, priestly costume, and ceremonies, as seemed consistent with scriptural principles. It has also retained the hierarchy, only substituting the king or queen regnant as the spiritual head of the church, instead of the pope. Its archbishops and bishops are lords of parliament, and appointed by the Crown. In respect, however, of both doctrine and

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ceremonies, the members of the United Church of England and Ireland are very divided among themselves, the great body being Arminian, while a smaller fraction profess to be evangelical, and not a few seem verging to popery. Episcopalians are somewhat numerous in Scotland, but the majority of them constitute a church of their own, quite independent of that of England.

Methodists are likewise a very numerous and influential body, particularly in England, and are under the spiritual authority of a "Conference," constituted only by their clergy, to the absolute exclusion of lay members. They are divided, however, like other sects; the bulk of them, called Wesleyan, being Arminians, and a smaller body, the followers of Whitfield, being Calvinists. Each of these, however, is divided into several bodies, forming so many separate churches, ruled by conferences of their own.

In 1817, the Lutherans and the Calvinists in the duchy of Nassau were united into one body, under the name of the *Evangelical Church.* Similar unions have since taken place in Paris, Frankfort, Prussia, Bavaria, Baden, Hesse, Anhalt-Bernburg, Waldeck, and other parts of Germany. But this union having been effected in most of these places by the influence of the civil authority, amounting almost to compulsion, is believed to be neither very sincere, nor likely to last.

But the task would be endless to mention in detail all the varieties of Protestant sects and churches; and, as it is impossible to obtain, in all cases, precise and trustworthy information respecting the number of people belonging to each, we have felt ourselves constrained to class them all together in the following table under the general name of Protestants.

Islam or *Mohammedanism*, is the religion professed by all the Ottoman and other Turks and Tartars in the Russian and Turkish empires, who are all *Soonee*, or orthodox; and those of Russia are under the spiritual charge of two grand muftis, one of whom resides at Kazan, and the other at Simferopol in the Crimea. Those of Turkey acknowledge the supremacy of the Sultan, as the representative and caliph, or vicegerent of their prophet, and, as such, the spiritual head of their religion; but under the Sultan the management of the Mohammedan church and its spiritual concerns is delegated to the Grand Mufti, or Sheikh-ul-Islam, who resides at Constantinople, and is also the chief of the *Ulema*, or body of the clergy and lawyers of the empire. *Judaism* is, of course, the religion of the Jews who are scattered over Europe. The great bulk are Talmudists, or receivers of all the traditions that have accumulated for ages, and almost overwhelmed and superseded the law as delivered by Moses; but they have no general head, either spiritual or temporal, no sacrifices, no temple, and no altar. They are waiting in patient expectation of the coming of the Messiah, their prophetic king, who is to gather them from their long dispersion, and lead them again in triumph to Jerusalem, loaded with the spoils of the Gentiles. A small body of Jews or Israelites, who reject the Talmud and traditions, and acknowledge only the law itself, are known by the name of Karaites, and have their headquarters in the Crimea. A few *heathens* are still to be found among the Ugrian tribes on the shores of the Frozen Ocean, and among the Kalmucks and other Mongols in the S.E. of Russia, on the shores of the Caspian Sea, and among the tribes of the Caucasus.

The following table conveys a general view of the numbers of people belonging to each of the principal religions professed in Europe, as given in the Weimar Almanac for 1837, and there is no reason to suppose that the relative proportions are changed to any considerable amount, except perhaps in Ireland, where, within a few years, through the effects of famine, pestilence, and emigration, the numbers of the Catholic population have been very considerably reduced. In the pre-eminently Catholic countries of Italy, Spain, and Portugal, though Protestant churches are not permitted, there are nevertheless very considerable numbers of foreign Protestants always resident; and in Sardinia, in particular, besides the churches of the Waldenses, which have been always allowed to exist among the valleys of the Alps, they have been allowed last year (1854) to erect one in Turin itself, to the great chagrin of the Catholic clergy. To the numbers of religionists after mentioned are to be added about 350,000 Armenians, a branch of the Oriental Church, quite distinct from the Arminians of Western Europe, scattered over the south-eastern parts of Europe; the Mohammedans of Turkey and Russia, about two or three millions; and the Pagans of the Arctic coasts and the Caucasus, the numbers of whom are not known, but are not very considerable.

Names of States.	Roman Catholics.	Orthodox Greek Church.	Protestants.	Jews.
Austrian Empire	27,116,730	2,900,000	2,801,500	480,250
Belgium	4,000,000	...	20,000	780
Denmark	2,000	...	2,040,650	6,000
France	31,000,000	...	1,400,000	60,000
Great Britain and Ireland	6,600,000	...	18,676,687	12,500
German Minor States	4,984,740	...	9,214,550	245,089
Greece	...	811,185	...	...
Ionian Islands	35,200	148,017	...	5,500
Italian States	16,943,314	80,000	...	48,430
Netherlands	280,000	...	2,100,000	50,000
Portugal	3,530,000	...	...	...
Prussia	4,993,720	...	8,000,000	167,700
Russia	7,000,000	36,531,427	2,800,000	900,000
Spain	13,944,259	...	...	...
Sweden and Norway	4,000	...	4,023,200	850
Switzerland	800,000	...	1,300,000	1,900
Turkey	310,000	2,830,000	3,000	250,000
	120,543,963	43,300,629	52,369,587	2,228,999

Progress of civilization.

Europe has been gradually advancing from poverty and barbarism to wealth and refinement since the tenth century; but the progress of the different nations has been very unequal. No single cause has contributed so much to their improvement as commerce; and hence the first advances have always been made by maritime states; and the progress of the different communities has been nearly in proportion to their vicinity to the sea, or the facility of their communication with it. The small republics of Italy and the Hanse Towns were the seats of industry, wealth, knowledge, and freedom; while slavery, ignorance, and rapine, reigned in the countries around them. The tendency of commerce to enrich a country seems to depend on its power to create disposable capital. Though a certain species of opulence exists among the great land-holders of agricultural countries, those masses of disposable capital which give vigour to industry, and supply the means of great improvements, are only found in commercial states. Commerce also favours the growth of manufactures, and these two species of industry raise up a middle class, closely allied with the great body of the people. It is among this class that ideas of civil and religious liberty take their rise, and find their firmest supporters; whereas in countries entirely agricultural, liberty means only the domination of the aristocracy. The spirit of liberty once introduced, laws are improved, prejudices hostile to industry extinguished, and new vigour infused into every branch of society. It is thus that freedom and wealth have generally followed in the train of commerce; and that the commercial states have led the way in those improvements which have so much ameliorated the condition of Europe. When the Italian republics flourished, however, Europe was not in a state to be much benefited by the lights which their experience afforded. The Dutch republic, which flourished at a later period, gave a more striking demonstration of the advan-

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tages of industry, freedom, toleration, and good government, at a time when neither liberty nor toleration were understood even in England, and when industry was in a very low state all over Europe. The example of the Dutch furnished statesmen with new ideas, and had a sensible influence on the policy of England, France, and other countries. The genius of Peter the Great derived from this small republic the seeds of those improvements by which civilization was spread over the vast empire of Russia. The superiority which the Dutch possessed has since been transferred to Britain, and she has acquired with it the privilege of instructing other nations in the sources of public wealth and the science of government.

The Reformation had a material effect in accelerating the progress of society. It put an end to a multitude of abuses and prejudices adverse to improvement, and inspired the human mind with a new activity. Those countries in which it took no root seemed to have had their progress arrested; while others, less favoured by nature, derived new life and vigour from its influence. Italy and Spain, now so far behind Britain, France, and Germany, were the first countries in Europe for knowledge, wealth, and industry, at the period of the Reformation. The establishment of the Protestant religion has produced a more liberal spirit among the Catholics in those countries where the two churches exist together; but in those countries where Protestantism never obtained a footing, the dread of its introduction threw the government more and more into the hands of the clergy; the clergy, armed with power, became more jealous and intolerant, and nearly put an end to all freedom of thought. The literary glory of Spain expired some time after the Reformation; and Italy was checked in her career. The older writers of these countries breathe a spirit which would not be tolerated at the present day, nor does society there afford the elements out of which such characters could be formed. And thus it happened that the very same event which called forth the powers of the human mind in the north of Europe, extinguished the intellectual activity of the south.

The improved means of internal communication in countries in modern times have had a considerable effect upon the state of society. In ancient times free states were necessarily small, because when neither the press nor the post existed, that union of sentiment necessary to control the conduct of men in power could not be effected among a large population scattered over a wide space. A number of free states sprung up in Greece, because that country, divided by mountains and arms of the sea, afforded natural means of defence to such small societies as could then exercise the functions necessary to the preservation of freedom. It is a mistake to suppose that, in these states, a greater extent of territory could have been united under one government by adopting the representative system. The resolutions of a body of representatives would command no more respect from a government than those of as many private individuals, if they were not constantly supported by the opinions of the mass of society; and this requires such a rapid and general circulation of intelligence as could not then exist. The small size of the Grecian states was a necessary condition of their freedom; but it was a serious disadvantage, not only because it lessened the commercial intercourse between the different parts of the country, but because such small communities had not strength enough to resist a great force from without; and hence these states fell a prey to the superior power of the Macedonian monarchy. The whole of the south-west of Europe exhibits the physical features of Greece upon a larger scale. Its surface is broken into numerous sections by gulfs and mountains, and abounds in natural barriers. Favoured by these circumstances, the different communities in this quarter of the world in modern times enjoyed a certain degree of independence and security, which hastened their progress in civilization. Russia, which occupies the largest plain in Europe, has been the last reclaimed from barbarism, though still very far from being civilized. So long, however, as the means of communication remained very imperfect in modern Europe, free governments were confined to small states, and the larger states were abandoned to feudal tyranny or military despotism; but the science of government has gradually improved, as knowledge, commerce, and the arts have advanced; and at present the admirable inventions of the post and the press, steam navigation, railways, and the electric telegraph, give such a rapidity to the circulation of public sentiment, and such facilities for congregating multitudes of men, that twenty millions could be almost as easily united in defence of their rights as the small population of Attica in the time of Xerxes.

The progress of improvement tends to level all distinctions among states, but those founded on the extent of their natural resources. Capital, skill, intelligence, and all acquired advantages, tend to an equilibrium. When Europe was overrun with barbarism, the city of Venice, by its commercial wealth, was a counterpoise to two or three of the great monarchies of the continent. The discovery of America, and of a passage by sea to the East Indies, gave a new direction to commerce, and undermined the greatness of that city. The Dutch republic rose by its freedom and industry, and was able, in the time of Charles II., to dispute the empire of the sea with the combined powers of England and France. But England increased her commerce, and improved her constitution; and having a larger and more fertile territory, as well as a greater population, she obtained at length an ascendancy over Holland, deprived her of the empire of the sea, and stript her of most of her colonies. At the beginning of the seventeenth century, Spain and Turkey were the first powers in the west and east of Europe, and inspired their neighbours with the dread of conquest. Sweden ruled with undisputed sway in the north; and Russia, now so formidable, was scarcely known. Spain, under a better government, might recover a part of her influence; but the Turkish empire seems near its dissolution; and the importance of Sweden and Holland is gone irretrievably, in consequence of the growing strength of the neighbouring powers. The extent of territory and the immense natural resources of Russia must, in the end, render her highly dangerous to all the other powers of Europe, if the empire do not fall to pieces from its own weight, or get into disorder from the vices of its government, or the barbarism, ignorance, and corruption, of its people.

Commerce and manufactures.

During the last century the commerce and manufactures of Britain have been progressing continually and rapidly, and have now reached an enormous degree of development, without a parallel in the history of the world. The long peace has enabled the other states of Europe to direct their attention to the same means of wealth, and some of them, as France and Germany, have become very active and powerful competitors. Still, the natural advantages which Britain enjoys, her accumulated capital, and the spirit of her people, have enabled her to keep ahead in this rivalry. Her abundant supplies of iron and coal have made her the mechanical workshop of the world; and it is principally to British ingenuity, skill, and industry, and the application of British capital, that the states of Europe are indebted for the steam navigation, the railways, and the electric telegraph, by means of which they are now so intimately connected with each other and with the other quarters of the world. Britain is a hive of manufacturing industry, of which cotton goods, woollen cloth, and iron articles, are the principal branches. The same may be said only of some parts of France, and more generally of Belgium, Germany, and Switzerland. Of other countries the manufactures are unimportant; raw produce, and such quasi manufactures as

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pitch, tar, wine, and oil, forming the staple articles of their trade.

By means of steam-vessels, communication between all the maritime regions of Europe has been rendered easy and certain, while the seaboard has been connected with the inland regions by railways running in all directions. During the latter half of the last century, and the earlier part of the present, England was covered with a net-work of canals, forming navigable communication between all her principal towns and rivers. Belgium and Holland have long been famous for their canals. In France, likewise, the great rivers were connected in the same way, and the great canal of Languedoc formed a navigable communication between the Bay of Biscay and the Mediterranean Sea. In Prussia, likewise, and in Russia, the great rivers have been connected by canals; and in Sweden, the Gotha canal extends from the Cattegat at Gottenburg to the Baltic, near Stockholm, through the lakes Wener and Wetter. These very useful means of transport have now, however, been very much, if not entirely, superseded by railways. Of these, England is covered with a net-work, as she was with canals, and uninterrupted lines of communication extend from near the Land's End through Scotland to the Moray Firth. In Scotland, Ireland, France, and Germany, the principal cities and towns are connected by railways; and in Russia, we understand that one is forming to connect St Petersburg with Moscow and the Black Sea. In Italy, Milan and Venice are connected, and railways are projected at least in other parts of the country. The later invention of the electric telegraph is likewise extending everywhere across seas and continents; but the whole system of telegraphs and railways will be understood at once by a glance at a map, far more easily and more perfectly than from volumes of verbal description.

States.

Considered in respect of political constitution and civil government, the states of Europe may be arranged in six classes. The first class comprises 4 empires, the sovereigns of which are absolute monarchs; the second, 16 kingdoms, partly absolute and partly constitutional; the fourth, 7 grand-duchies, all monarchies; the fifth, 24 duchies and principalities, likewise all monarchies, partly constitutional and partly absolute; and the sixth, 32 republics. The third class comprises 2 nondescripts, both monarchies indeed; but, in the one case, the sovereign retains the subject title of Elector of the head of an empire that no longer exists, and the sovereign of the other is at once the spiritual sovereign of the Roman Catholic world, and the temporal sovereign of that portion of Italy called the States of the Church. The following table contains the names, territorial extent or area, and the population of these several states at the dates attached to them respectively. The grand total of the population, as it is not all of the same year, can only be considered as an approximation to the truth.

Names.	Area in Square English Miles.	Population.	Date.
I. EMPIRES—			
French	204,000	35,781,628	1851
Austrian	257,760	36,514,466	...
Russian	2,000,000	54,092,300	1846
Ottoman	123,743	10,500,000	1844
II. KINGDOMS—			
Great Britain and Ireland	121,779	27,621,862	1851
Prussia	106,302	16,935,420	1852
Belgium	12,569	4,359,090	1849
Netherlands	13,890	3,397,851	1853
Spain	176,480	14,216,219	1849
Portugal	34,500	3,487,025	1851
Denmark	22,680	2,296,597	1850
Sweden	170,240	3,482,541	...
Norway	122,460	1,328,471	1845
*Bavaria	29,000	4,559,452	1852
*Hanover	14,600	1,819,253	..
*Saxony	5,705	1,987,832	...
*Wirtemberg	7,568	1,733,263	...
Sardinia	28,830	4,916,084	1848
Two Sicilies	41,521	8,704,472	1851
Hellas, or Greece	10,206	1,002,112	1852
III.			
*Electoral Hesse	4,439	755,228	1852
States of the Church	17,048	3,006,771	1850
IV. GRAND DUCHIES—			
*Baden	5,850	1,356,943	1852
*Hesse-Darmstadt	3,761	854,314	...
*Mecklenburg-Schwerin	4,845	541,449	1853
* ... Strelitz	767	99,628	1851
*Oldenburg	2,400	282,114	1852
*Saxe-Weimar	1,419	262,524	1853
Tuscany	8,302	1,815,686	1854
V. DUCHIES AND PRINCEDOMS.			
*Nassau, D.	1,757	429,341	1852
*Brunswick, D.	1,507	271,943	1853
*Saxe-Coburg-Gotha, D.	799	150,412	1852
* ... Meiningen, D.	888	166,364	1853
* ... Altenburg, D.	510	132,738	1850
*Anhalt-Dessau-Coethen, D.	665	171,759	1852
* ... Bernburg, D.	340	52,641	...
*Reuss-Greiz, P.	145	35,159	1853
* ... Schleiz, P.	448	79,824	...
*Schwartzburg-Rudolstadt, P.	410	69,038	1852
* ... Sondershausen, P.	359	60,847	...
*Lippe-Detmold, P.	437	106,615	1853
* ... Schaumburg, P.	206	30,226	1852
*Waldeck, P.	461	59,697	1852
*Hesse-Homburg, P.	168	24,921	...
*Liechtenstein, P.	53	6,351	1842
*Kniphausen	17	3,035	1852
Parma, D.	2,184	507,881	1853
Modena, D.	2,073	586,458	1850
Monaco, P.	50	6,500	
Moldavia, P.	16,000	1,400,000 ?	1844
Wallachia, P.	30,000	2,600,000 ?	...
Servia, P.	12,000	1,000,000 ?	...
Montenegro	1,400	100,000 ?	
VI. REPUBLICS—			
*Frankfort	91	77,971	1852
*Lubeck	142	54,166	1851
*Bremen	106	79,047	1849
*Hamburg	151	200,690	1852
Zurich	647	250,698	1850
Swiss Confederation.			
Bern	2,583	458,301	...
Lucerne	600	132,843	...
Schweiz	350	44,168	...
Uri	420	14,505	...
Unterwalden-Upper	260	13,799	...
... Lower		11,339	...
Glarus	281	30,213	...
Zug	185	17,461	...
Friburg	496	99,891	...
Soleure	256	69,674	...
Basel-City	185	29,698	...
... Country		47,885	...
Schaffhausen	116	35,300	...
Appenzell-Outer	160	43,621	...
... Inner		11,272	...
St Gall	760	169,625	...
Grisons	2,540	89,895	...
Aargau	499	199,852	...
Thurgau	267	88,908	...
Tessin	1,041	117,759	...
Vaud	1,190	199,575	...
Valais	1,675	81,559	...
Neufchatel	281	70,753	...
Geneva	91	64,146	...
Ionian Islands	1,200	239,297	1852
Saint Marino	27	7,600	1851
Andorre	144	15,000	
Total	3,691,680	258,678,856	

NOTE.—The principality of *Monaco*, though nominally an independent sovereignty, is practically under the domination of Sardinia.

Europe. Finances.

In financial importance Britain stands at the head of all these states; for not only is her annual revenue the largest, excepting that of France, but she enjoys besides the unenviable pre-eminence of being burdened with the largest debt. The bad practice of anticipating revenue by borrowing money is common to them all; and, as will be seen in the table, only some of the less important have escaped the ever-growing evil. Within the last twenty years the debt of Austria has increased more than threefold, and now the French emperor is borrowing largely to pay the current expenses of the war in which he and the British government are engaged with Russia. The governments of Spain and Greece are virtually bankrupt, being neither able nor willing to pay either principal or interest of their large debts. Norway, on the contrary, the poorest country in Europe, has set the bright example of paying off that portion of the Danish debt with which she was burdened when separated from that monarchy in 1814, while the Danish portion has gone on increasing. The Ottoman Sultan has only escaped by virtue of his want of credit.

Country.	Annual Revenue.	Debt.
Great Britain and Ireland	£56,000,000	£760,000,000
France	62,000,000	275,000,000
Austria	25,000,000	180,000,000
Russia	35,000,000	170,000,000
Prussia	15,000,000	32,000,000
Spain	15,000,000	120,000,000
Turkey	6,500,000	... ...
Netherlands	6,000,000	100,000,000
Belgium	5,000,000	29,000,000
Denmark	1,500,000	13,750,000
Bavaria	3,000,000	16,146,000
The Two Sicilies	4,500,000	16,800,000
Sardinia	5,000,000	24,000,000
Hanover	1,300,000	5,474,000
Baden	1,680,000	5,485,000
States of the Church	2,381,000	20,000,000
Portugal	2,850,000	18,000,000
Kingdom of Saxony	1,650,000	6,500,000
Sweden	1,040,000	
Norway	650,000	None.
Tuscany	1,250,470	
Greece	860,000	4,176,000
Modena	340,000	
Parma	76,000	380,000
Wirtemberg	1,000,000	4,842,000
Smaller German States together	5,500,000	17,000,000
The Swiss Cantons all together	650,000	

Their annual revenues and the amount of their debts are stated in the above table, in the nearest round numbers, and in sterling money, which will give a sufficiently near approximation to sums that are constantly varying, and in many instances not certainly known.

Military forces.

Though there has been a general peace in Europe for the long period of forty years, yet their mutual jealousies have made it seem necessary to the Continental governments at least to maintain large standing armies. Russia, safe from foreign invasion, has long been preparing large armaments for purposes of aggression on her weaker neighbours, and of domination over all the rest; and at last her overt acts of aggression on Turkey have provoked a war with Great Britain and France, who have armed in defence of their ancient ally the Sultan, and with the view of not only maintaining the balance of power in Europe, but of effectually checking the undisguised attempts of the Czars of Russia at universal dominion. In these circumstances, with all Europe arming or beginning to arm, any numerical statements of their military forces, however approximately correct when written, may have become quite erroneous by the time they are published. The following table, therefore, contains only the declared numbers respectively of the peace and war establishments of the Continental armies, with the exception of that of France, which gives the actual number of men on foot, as stated in the emperor's address to his legislative council in December 1854.

Countries.	Peace.	War.
Austria	...	670,000
Russia	...	1,500,000
Prussia	129,000	525,000
France	...	581,000
Britain	128,000	...
Spain	70,000	...
Portugal	29,000	53,326
Two Sicilies	56,043	102,932
Sardinia	47,524	...
Belgium	73,998	100,000
Netherlands	57,959	...
Denmark	37,043	...
Sweden	7,692	144,000
Norway	...	23,484
Tuscany	15,189	...
Parma	2,773	4,033
Modena	3,500	14,656
States of the Church	17,365	...
Smaller States of the Germanic Confederation	142,686	224,000
Swiss Confederation	...	108,000
Turkey	...	450,000
Greece	9,848	...

Maritime force.

The maritime powers that maintain efficient navies worth notice are, Britain, France, Russia, Austria, Turkey, Sardinia, Netherlands, Denmark, Sweden and Norway. In December 1854, the British fleet, in commission and actual service, consisted of 142 steamers and 104 sailing ships, with 63,000 men; that of France, of nearly the same number of vessels altogether, though not so many steamers, with 62,000 men. The Russian fleet in the spring of 1854 consisted of 52 line-of-battle ships, 48 frigates, and 84 smaller vessels (besides gun-boats), with 9000 guns and 62,000 men. Austria possessed 104 vessels carrying 742 guns; Turkey, 70 vessels, with 34,000 seamen and 4000 marines; Sardinia, 19 vessels, with 359 guns; the Netherlands, 88 vessels, with 2000 guns and 6180 men; Denmark, 120 vessels, with 883 guns, and 2000 men; Sweden, 74 vessels besides gun-boats; Norway, 19 ships besides gunboats, with 500 men.

In Europe there are two great national confederacies, the Germanic and the Swiss; but in neither of them is there so close a union of the sovereignties that compose it as there is in the United States of North America. In Germany, indeed, there is no principle or feeling of unity among either princes or people, and their confederation, as such, enjoys neither influence nor respect at home or abroad. In Switzerland, on the contrary, recent circumstances seem to have produced a closer and more intimate union, and given to the federative assembly the authority indispensable to the efficient working of a central government.

SKETCH OF THE SEVERAL STATES.

Britain.

Britain, though much smaller in extent than any of the other states of the first rank, is the wealthiest, and consequently the most powerful, of the whole. It enjoys a moderately good climate, rather cold and moist, but equable, a soil

and garrisoned by Sardinian troops. *Moldavia, Wallachia,* and *Servia* are independent only in respect of internal administration, but acknowledge the imperial sovereignty of the Ottoman Sultan. *Montenegro* is practically independent, under the rule of its Vladika, or hereditary bishop, but is not the less considered as an integral part of Turkey. *St Marino,* situated within the States of the Church, is under the protection and control of the Pope, as *Andorre* is of France. The *Ionian Islands* are likewise under the protection and control of the British Government, and garrisoned by British troops. *Kniphausen* is only a lordship, and *Hesse-Homburg* a landgraviate. The asterisks mark the smaller states of the Germanic Confederation.

Europe. less fertile in grain than that of France, but affording better pasturage, an extensive line of sea-coast, with numerous harbours, a natural and well-defined frontier, which no invading army can pass on foot, a good commercial position, and the largest fields of coal in Europe; but all these advantages have contributed less to her aggrandizement than the excellence of her laws and political constitution. The progress of Britain within the last hundred years, and especially within the last half century, has been wonderfully great. The British isles contain about 76,000,000 of acres, of which about two-thirds are in cultivation, and more than one-third waste or uncultivated. About half of the waste land is in Scotland, where the cultivated soil forms little more than a fourth part of the total area of the country, while in England it forms about 67 per cent., and in Ireland 70 per cent., of the surface. So great, however, has been the progress of agricultural improvement, that, though the population has doubled itself within the last fifty years, the production of food has fully kept pace with it. The progress of Britain in manufacturing industry has been still more rapid and more remarkable than even in agriculture; and in this respect her natural advantages are more exclusive. She has a good supply within herself of the raw material of her staple manufactures of woollen cloths, iron, and linen; and her means of procuring silk and cotton are equal at least to those of her neighbours. In enterprise and commercial activity, her merchants take the lead among the nations of Europe; and the removal of all restrictions, and the full introduction of the principles of free trade have given such a stimulus to their exertions as transcends all former example. The number of ships employed in her foreign and colonial trade in 1853 was 35,303, with a burden of 7,797,530 tons; and the number of registered British seamen was 253,896. Her military forces, in respect of numbers, make a very poor appearance beside those of the other great states; the peace establishment scarcely exceeding 120,000 men for colonial as well as home service. The amount, however, of her naval forces is more formidable. In December 1854, the number of seamen and marines on board the armed fleet was about 63,000.

France. France enjoys, upon the whole, greater natural advantages than any other country in Europe. Her territory is above a half larger than that of Great Britain and Ireland, and both her soil and climate are better,—the climate being less equable indeed, but there being a greater amount of summer heat to bring the fruits of the earth to perfection. She has a greater proportion of arable land than any of her neighbours; the natural means of communication throughout her provinces are abundant and easy; she is well provided with all the useful metals except tin; and is better supplied with coal than any other country of Europe but Britain. Even during the distractions of her great revolution, though her foreign trade was annihilated, her agriculture and manufactures were extended and improved, her population was increased, and its condition ameliorated. The surface of France contains about 128,000,000 of acres. It is estimated that, of this quantity, the waste land, including roads and rivers, amounts to an eighth part; the arable land to near a half; the woodland and pasture land and meadows, each to about a seventh; the vineyards to a twenty-fifth part; wild-land, quarries, buildings, orchards, gardens, olive and other plantations, making up the remainder. In addition to the vegetable productions that grow in England, the climate of France enables her to raise vines, olives, mulberries, and chestnuts. Wine and olive oil are two of her most valuable productions. The cotton trade has been for some time rapidly extending over the northern and eastern provinces; and Lyons has been long famous as the centre of the silk trade of Europe, a branch of manufacture that has been brought to great perfection in that city. The manufactures of woollen cloth, flax, hemp, and iron, are also very extensive, and have been carefully fostered under the protective system, which still prevails here, as elsewhere on the Continent, notwithstanding the example which has been set by Great Britain. Towards the end of the seventeenth century, the territory of France, then equal, or very nearly equal, to its present extent, appears to have contained about 20,000,000 of inhabitants. In 1791, it was found to be above 26,000,000, and in 1851 nearly 36,000,000. The government always maintains a large standing army, amounting on the peace establishment to about 350,000 men, but actually in December 1854 to 581,000. Her armed fleet on service is about equal in number of ships to that of Britain, with 62,000 men.

Netherlands. The seven northern provinces of the Netherlands are commonly called by the name of one of their number, Holland. They form a very low and flat country, many parts of which are from 10 to 20 feet below high-water mark on the adjoining sea-coasts; and altogether the country is so flat, that to those approaching it from the rivers, and some parts of the coast, the trees and spires seem to rise out of the water. It is defended from the sea and the rivers by huge dykes, the raising and maintaining of which has cost an enormous expense and amount of labour, and is a continual object of public solicitude. It is everywhere intersected by sluggish rivers and canals; and in consequence of so much water, and its unsheltered exposure to the sea breeze, the climate is humid and foggy; but, notwithstanding all disadvantages, the industry of the people has multiplied cattle and pasture-grounds; and besides these, wheat, flax, and madder, are raised in the northern districts; and in the south tobacco and different kinds of fruit-trees cover the fields. The area of the country contains about 7,614,000 English acres, of which about two-thirds are cultivated, the remainder being waste, or occupied by water, heaths, and peat-bogs. It is inhabited by the *Dutch*, a branch of the Low German family of nations, who, besides being patient and persevering agriculturists, are also largely engaged in foreign commerce. The population amounted at 31st December 1853 to 3,203,232, being an increase of 35,226 on the numbers of the preceding year. The army on permanent duty amounted to 20,488; the naval force to 6087 men, of whom 2322 were employed in the service of the Indian Archipelago.

Belgium. The people of the southern provinces have assumed the national name of Belgians (Belges), from the *Belgæ*, by whom the country was inhabited in the days of Julius Cæsar; though there is no reason to suppose that there is much, if any, family connection between them. They consist of two distinct nations, the Flamandes or Flemings, who inhabit the northern provinces to the number of about 2,500,000, speaking a dialect of the Low Dutch; and of Walloons and French, who inhabit the southern parts of the country to the number of about 2,000,000. French is the official language of government, and great efforts have been made to extend its domain, but the national spirit of the Flemings has been roused to the defence of their native tongue, and there has been a great revival of Flemish literature, while French literature in Belgium has not made the same progress. The Catholic party, which predominates in the north, has endeavoured to turn the spirit thus excited to its own purposes, and the kingdom is divided against itself. The southern part of Belgium is rather high and rugged, but to the north the country sinks into a flat plain, traversed by rivers and canals, diversified by woods, arable fields, and meadows, and thickly studded with towns and villages. The inhabitants are renowned for their industry and manufacturing talent, and every effort has been made by the government to foster improvements. The principal towns are connected with each other, and with France and Germany, by railways. There are large deposits of coal and iron, and the iron trade is carried on with great activity, particularly at, and in the neighbourhood of, Liège. A perpetual obligatory neutrality having been imposed upon Belgium by

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the treaties of 1831 and 1839, by virtue of which the kingdom was constituted, the naval and military forces are consequently unimportant.

Switzerland.

Switzerland is a country of mountains and valleys and lakes, and the cultivable soil forms but a small proportion of its area. It is the highest ground in Europe, and sends out large rivers to both the North Sea and the Mediterranean. Agriculture and pasturage are the prevalent branches of industry; but the cotton manufacture has likewise been introduced, and is carried on to a considerable extent in some places. The north-eastern part of the country is inhabited by Germans, or people who speak dialects of the German language; the south-western parts by people who speak French; the canton of the Grisons by people who speak a dialect of the old Romance, or bastard Latin, and the canton of Tessin by people who speak Italian. The neutrality of Switzerland is likewise allowed by its neighbours, and its independence guaranteed by the great powers. It is divided into 22 cantons, which form 25 sovereign states; but, in consequence of recent events, they have all become subjected to a central federal government, which controls their movements.

This confederation was formerly almost as loose as that of the German states; but the Jesuits having got possession of Lucerne, a *sonderbund*, or separate league, was entered into by the Roman Catholic or Forest Cantons for the defence of the holy fathers and their unpopular institutions against the attempts that might be made by the other cantons, or the general confederacy, to dislodge them. A short war, ending in the defeat of the troops of the Sonderbund, and the capture of Lucerne, left the Forest Cantons at the mercy of the General Confederation, and a new Federal Constitution was formed and adopted by the Federal Diet, Sept. 12, 1848. The sovereignty of Switzerland is vested in the Federal Assembly, consisting of two divisions, namely, the National Council, and the Council of the States. The members of the former are nominated in the cantons, in the proportion of one representative for 20,000 inhabitants; and the latter consists of 44 senators, two for each entire canton, and one for each half of the divided cantons. The Federal Assembly chooses among all the Swiss citizens who are eligible for the National Council a Federal Council, consisting of seven members, who continue in office for three years. After every entire election of the National Council, the Federal Council is also renewed; and over all these is a president and a vice-president of the Confederation, nominated annually in a conjoined sitting of the two sovereign authorities, and not re-eligible for a year. Only the Confederation, represented by the two councils, has the right of making war and peace, and treaties of alliance, commerce, and customs; and it is only the Confederation, and not the separate cantons, that has official relations with foreign governments, and regulates the general posts and tolls. The city of Bern was selected in Nov. 1848 to be the Federal capital.

Germany.

Germany occupies a large portion of the middle region of Europe, lying nearly across the Continent, from the head of the Adriatic Sea to the Baltic. The southern provinces consist of large elevated plains and valleys, bordered by lofty mountains; but towards the N. it sinks into a plain, or flat country, of seemingly boundless extent, intersected by the large rivers that flow from the southern mountains. The climate is naturally modified by the configuration of the ground. In the northern plains it is not cold, but humid and variable; in the higher country to the S. it is drier, but also, owing to the elevation, colder, or, to speak more correctly, liable to greater extremes of heat in summer and of cold in winter. Grain of almost every kind is cultivated, and produced in abundance; and in the valley of the Rhine the vine is cultivated as far N. as 51°. Wine is likewise produced in the lower and more sheltered valleys of the S. and E. The great bulk of the people are agricultural, but manufacturing industry is also very widely extended in various provinces. A large portion of the country is included in one or other of the two great rival monarchies of Austria and Prussia; the remainder is divided into a number of petty states, which form, with Austria and Prussia, the Germanic confederation. The people call themselves *Deutsch;* and are divided in respect of language into the two great families of Hoch Deutsch and Platt Deutsch, or High Dutch and Low Dutch, who speak dialects of German that differ very considerably. The general literary language of the country is a modified and refined form of the High Dutch, first devised, it is said, by Luther, in his translation of the Bible. Before the dissolution of the "Holy Roman Empire," in 1806, in consequence of the wars of the French Revolution, Germany was parcelled out among upwards of 300 sovereign states, including in the number about 50 free imperial cities. At the general settlement of the affairs of Europe, at the congress of Vienna, only 40 of these were allowed to recover or retain their independence; and by compact, of date 8th June 1815, these formed themselves into a *bund* or confederation, the object of which was the maintenance of the external and internal security of Germany, and the independence and inviolability of the confederated states.

The confederation was to be represented by a federal diet, composed of the plenipotentiaries of all the states, and of which the plenipotentiary of Austria was to be always the president. The diet held its sittings at Frankfort-on-the-Maine, and was to have at its disposal a fund contributed by the members, and a federal army to be furnished by the states in the proportion of one soldier for every 100 inhabitants for the active army, and of one in 200 for the army of reserve. The army when assembled was to be commanded by a general named by the diet, and was to be arranged in ten active divisions, and one division of infantry of reserve. Of these

	Men.
Austria was to furnish the 1st, 2d, and 3d, amounting to	94,822
Prussia, the 4th, 5th, and 6th	79,484
Bavaria, the 7th	35,600
Wirtemberg, Baden, and Darmstadt, the 8th	30,150
Saxony, Cassel, Nassau, and Luxemburg, the 9th	23,263
Hanover, Holstein, Lauenburg, Mecklenburg, Oldenburg, Brunswick, Hamburg, Lubeck, and Bremen, the 10th	28,067
And the 11th division to complete the garrisons of the federal fortresses, to be furnished by the Saxon duchies, Anhalt, Schwartzburg, Hohenzollern, Liechtenstein, Waldeck, Reuss, Lippe, Homburg, and Frankfort	10,902
Original force of the federal army	302,288

These are the numbers of the contingents as originally allocated in 1815; but a report recently published by the military commission of the diet at Frankfort shows the total strength of the federal army (being the sum of the federal contingents) to be now 525,037 men, constituted as follows:—

Divisions.		Men.
I. II. III.	Austria	153,295
IV. V. VI.	Prussia	170,509
VII.	Bavaria	50,236
VIII.	Wirtemberg, Baden, Hesse-Darmstadt	47,557
IX.	Saxony, Electoral Hesse, Nassau, Luxemburg, Limburg	35,336
X.	Hanover, Brunswick, Oldenburg, the Hanseatic towns, Mecklenburg	49,918
Reserve division of infantry		18,186
	Total	525,037

These are distributed among the different arms as follows:—

Infantry (of whom 28,621 are sharpshooters)	404,502
Cavalry (with 72,032 horses)	71,149
Artillery (with 7424 horses)	40,270
Engineers	5,745
On the different staffs	3,371
Total	525,037

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In addition to the above are—

Surgeons	1,470
Transport department	16,838

The siege artillery consists of 250 guns—viz. 122 cannon, 31 howitzers, and 97 mortars. The whole is tactically subdivided into 387 battalions, 409 squadrons, and 147 batteries, consisting of 1122 guns.

A recent plan for a new federal military constitution contemplates, besides an increase of 50,000 men in all, an increase of the artillery to the proportion of $2\frac{1}{2}$ guns to every 1000 men, instead of 2 to every 1000 as at present, and a reduction of the proportion of the cavalry to the infantry from one-seventh to one-eighth, on the ground that the increase of 50,000 men will be applied chiefly to garrison purposes. Whenever there is the least prospect of a federal mobilization, the unsatisfactory state of the contingents of the petty states is brought into greater prominence, but is always smoothed over by one or other of the greater powers for their own political connection's sake. Should the federal army ever be brought into the field there would be little more than the first seven divisions available, say 400,000; on the other hand, Austria and Prussia would always have further forces over and above their contingents, which they would willingly enough bring into federal service, as by that means the troops would be kept at federal cost, and, at the same time, procure a proportionate amount of ascendency for the nation to which they belong. One of the most faulty is the medical department: some small contingents have no surgeon at all; while one contingent has eight surgeons, another, of similar strength, has one. In exact proportion to the poverty and the mismanagement of these petty states is their pride and repulsive tendency, so that anything like an arrangement among themselves for a medical staff at joint expense is next to impossible.

The fortresses belonging to the confederation are Mentz, Luxemburg, and Landau.

From the first this confederation proved itself utterly inefficient for its intended purposes, and in 1848, in consequence of the spirit of revolution proceeding from France, the diet was superseded by a national assembly, which met at Frankfort and assumed sovereign powers, to which the princes of most of the states at least tacitly submitted. They appointed, or at least confirmed the appointment made by the diet, of the Austrian archduke John, as vicar of the empire, to administer its affairs till the election of an emperor or general sovereign. They established a national fleet; made war on the king of Denmark, for the purpose of wresting the duchies of Holstein and Schleswig from the Danish monarchy, and uniting them completely to the empire; and offered the imperial crown to the King of Prussia, which His Majesty felt himself constrained by circumstances reluctantly to decline. Their army, however, was beaten by the Danes, and re-action having commenced, all their projects proved abortive, and the assembly was dissolved. The vicar resigned his office in December 1849, when a series of negotiations ensued among the states with a view to the re-establishment of the *bund*, on such principles and with such powers as would ensure its efficient working for the general welfare of the German nation; but owing to their mutual jealousies, and more especially to the rivalry and irreconcileable pretensions of the two great powers, Austria and Prussia, these negotiations have had no more important result than the renewal of the federal compact of 1815, in all its inefficiency. It may be considered indeed as virtually dissolved, for the diet has no power of self-action, and no imperial authority; there is no central executive government; and there are no means of ensuring the combined action of the members for any object whatever, either civil or military. In the confederation are included the German provinces of Austria, Prussia, Denmark, and Holland, viz.—

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	Area in Square German Miles.	Population.
Austrian provinces	3,580	11,893,182
Prussian ...	3,387	12,314,700
Danish ...	175	526,850
Dutch ...	87	389,319
And the other states marked by asterisks in the preceding general table of the European states	4,283	16,088,708
	11,512	41,212,759

Zollverein.

In spite of the division of Germany into so many states, each possessing a right of toll, and its own custom-house regulations, the commerce of the country was very active and extensive, and promises to become continually more so through the operation of the *Zollverein*, or Great Customs Union, entered into very recently by most of the states at the suggestion and under the influence of Prussia, with the object of freeing the trade of Germany from the restrictions under which it was laid by the conflicting interests and regulations of so many separate and independent states, and the rapacity of so many needy princes. Tolls, therefore, or customs, are collected once for all at the general boundary of the states, and the produce is divided among them in certain proportions according to their interests. From this union, as it subsisted before the epoch of the revolutionary movements of 1848–9, Austria was excluded; but though not yet admitted into the union, Austria has become connected with it by a commercial treaty made with Prussia in 1853, the main principle of which is that the contracting parties should do nothing to prevent the free circulation of articles of trade in their respective territories, or absolutely prohibit the importation or exportation, or the transit, of any article of merchandise whatever, except tobacco, salt, gunpowder, playing-cards, and almanacs; the principal of these excepted articles, tobacco, being a government monopoly in Austria, but not in the other states. The duration of this treaty has been limited to 12 years from Jan. 1, 1854; and the members of the Zollverein have not only declared their adhesion to it, but have also prolonged till Dec. 31, 1865, the different conventions by virtue of which their union has been constituted.

The Zollverein includes Prussia, and all the minor German states, except—1. in the north of Germany, Holstein, with the portions of other states within its limits, Lauenburg, Mecklenburg, Hamburg, Lubeck, and Bremen; 2. in the south, the small principality of Liechtenstein, which is connected with the Austrian customs. Holstein, with the scattered portions of Oldenburg, Hamburg, and Lubeck inclosed within it, has been definitively incorporated with the Danish customs; but the duchy of Lauenburg has been left unattached, probably on account of its position, which enables it to profit by the transit of merchandise between Hamburg and Lubeck, and its tolls on the Elbe, which would become less productive and less profitable were it connected with either of the general systems of customs.

Austria.

The Austrian empire is one-fourth larger than France, and twice as large as Great Britain and Ireland together. It is almost entirely inland, having only a small extent of sea-coast, along the Adriatic. The south-western part is very mountainous; the northern contains the large plains of Hungary, Bohemia, and others, surrounded by mountains; and to the S. of the Alps lie the fertile plains of Lombardy and Venice. The climate is similar to that of France, but subject to greater extremes of heat and cold: the soil not much inferior, the grain and fruits nearly the same. Austria is richer in mineral wealth than any other state in Europe, and possesses coal, though not in great abundance. Iron of the best quality is found in Styria, Carinthia, and Lower Austria, and production is only limited by the want of fuel to smelt the ore. Quicksilver is found in abundance

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at Idria, in Carniola; and copper, zinc, sulphur, and various other metals and minerals of commercial value, are found in various places. Mines of rock-salt may be said to extend at intervals through Transylvania, Galicia, Hungary, Austria, Styria, and Tyrol; and those of Bochnia and Wielecska in Galicia are the largest salt workings in Europe. The land under tillage is about 34 per cent. of the total area; vines, orchards, and gardens, 3 per cent.; grass-land, 17 per cent.; forests and woodland, 26 per cent.; heaths, marshes, lakes, mountains, and other unproductive and uncultivable ground, 20 per cent. The cultivable soil, however, is fertile in grain; flax, hemp, hops, and fruits are extensively cultivated, and the forests furnish an ample supply of wood. The leading manufactures are linen, cotton, woollen, silk, leather, and works in metal and wood. The linen manufacture is carried on to the greatest extent in Bohemia and Moravia. Lombardy is the seat of the silk trade. The foreign trade is trifling, owing chiefly to her inland situation, want of navigable rivers, and the obstruction of mountains; but, by the introduction of steam navigation on the Danube, and the connection of her provinces with each other, and with other states, by means of railways, these disadvantages are in the way of being obviated or removed. Till 1848, the Austrian empire consisted of six distinct nations, with as many separate governments feebly united under one head. Now, however, the principle of centralization has been, and is continually being, more and more acted upon and enforced; and that, together with the removal or overcoming of the physical causes of separation, should naturally be followed by an increase of wealth, and strength, and political influence.

Prussia.

The Prussian territory is not much more than two-fifths of the size of that of Austria, and the larger portion of it lies within the limits of the great and comparatively barren plain which extends from the Bohemian and Carpathian Mountains to the Baltic Sea. The smaller and more fertile part of the Prussian territory, called the grand-duchy of the Lower Rhine, lies in the lower part of the basin of that river, and is separated from the main body of the kingdom by the intervention of Hanover, Saxony, and other German states. There are, besides, several smaller districts, scattered in the heart of Germany; and with a territory thus scattered and disjointed, the rank of Prussia as a great state has been sustained chiefly through the superiority of her internal organization, and the wary, temporising, and even shuffling policy of her government; forced upon them indeed by the defencelessness of a kingdom without natural frontiers, or physical centrality, or a people united by language, and national feeling, and interest. Agriculture is the chief occupation of the people, but in the Rhenish provinces the cotton, and in Silesia the linen manufactures are carried on to a great and increasing extent. Prussia necessarily maintains a large standing army, but has no naval power; the king, however, has recently purchased the port of Jahde from the Grand Duke of Oldenburg, for the purpose of a naval station, and has begun the formation of a fleet. The kingdom was, till recently, an absolute monarchy; but has now received a constitution.

Denmark.

Denmark is a portion of the great European plain, and may be described as almost uniformly level, with partial inequalities of surface, particularly in Schleswig and Holstein, and the islands of Funen and Zealand. The kingdom consists of two great divisions, the one a long peninsula, extending from the Elbe to the Scaggerrack, and the other a cluster of islands separating the Cattegat from the East Sea. The western coasts of the peninsula are a continuous level of marsh-land; the interior is dry and sandy; and the islands partake of the same characteristics. The soil of the lowlands is generally fertile, producing the finest pasture, and excellent corn crops. The climate is milder than the northern situation of the country would indicate; but the sky is very frequently obscured with vapours and moist fogs, and the summer lasts only from June till the middle of August. The climate, however, is not unwholesome. The mass of the population consists of Danes, who occupy the islands, North Jutland, and the northern part of Schleswig. Germans occupy the southern part of Schleswig, Holstein, and Lauenburg: Frisons and Angles live on the islands and other parts of the W. coasts. Agriculture and fisheries are their principal occupations. From 1660 till 1848 the kingdom was an absolute monarchy; but in the latter year a constitution was granted by the king; and the legislative power is now vested in two parliamentary bodies, the *Volksthing* and *Landesthing*, both consisting of elective members; the former resembling the House of Representatives, and the latter the Senate, of the Congress of the United States of North America, rather than the Lords and Commons of Great Britain. Denmark is a small and poor country, and her naval and military power corresponds with her small resources. She possesses in Europe the Faeroe Islands, and the large, volcanic, and poor island of Iceland, with a portion of West Greenland.

Sweden and Norway.

Sweden and Norway together occupy the Scandinavian peninsula, which consists of a huge mass of mountains, falling abruptly towards the Western Ocean, and in a series of long slopes towards the East Sea. More than a third part of the peninsula is more than 2000 feet above the level of the sea, and about 3700 square English miles of its surface are within the limits of perpetual snow. Of these elevated and snowy regions nearly 3000 square miles of the latter, and almost the whole of the former, are in Norway. The country possesses a great diversity of soil and climate. The summer of the lowlands of Sweden is warm and dry, but very short; the winters are long and severe. The climate, however, is generally wholesome and invigorating. The climate of Norway is less extreme; not so warm in summer, nor so cold in winter, but more humid and changeable than that of Sweden, and generally less salubrious. Agriculture and fisheries are the principal employments of the population. Sweden possesses mines of iron of the best quality, which are wrought with advantage. Sweden and Norway form two distinct states, with separate governments, but are united under one crown. Sweden possesses the form at least of a constitutional government; but, hitherto, has derived very little advantage from it in respect of social or material improvement; while, on the contrary, Norway, with a democratic constitution, has been steadily advancing since the epoch of her separation from Denmark and union with the crown of Sweden, in 1814. The military and naval power of both states is insignificant; and the country is too poor to maintain or require any considerable amount of foreign trade. Iron and timber are the principal articles of export.

Russian empire.

The Russian empire embraces nearly a half of the surface of Europe. It chiefly consists of an enormous plain, being little diversified by rising ground, except towards the Urals and the Caucasus in the S. and E., and in the province of Finland in the N.W. The northern part of the country is a cold and barren region of heaths and marshes; the central provinces are rich and fertile; the southern, mere steppes, or grassy, sandy, and salt plains, which afford, however, in their hollows, along the river-courses, abundance of excellent pasturage for cattle and horses. The population is chiefly agricultural, or nomadic; and the manufactures that are to be found in some places are more indebted to the fostering care of the government, and the high import duties, or absolute prohibition of foreign wares, than to native enterprise, for their origin and continuance. Russia is an immense military power, so far as that depends on the numbers of her armies; but the want of national wealth is such a drawback on military enterprise as she has not yet been able to overcome.

The origin of the Russians as a distinct branch of the

Europe. Slavonians, is a moot point among archæologists. They seem to have borne at one time the name of Antes, consisting of several tribes that formed a sort of confederation. In the ninth century, Ruric the Varangian, established himself in Novgorod the Great; and his successors, extending their dominion by conquest, established their capital at Kieff, where the dynasty reached the zenith of its power under Vladimir the Great, who introduced Christianity among his subjects, according to the creed and ritual of the Greek Church, A.D. 983. His empire was subsequently overthrown by the Poles and Lithuanians, and the greater part of it remained subject to Poland till the accession of the house of Romanoff. The eastern provinces beyond the Dneiper were conquered by Tartars, and remained under their dominion till the sixteenth century. The city of Moscow was founded by Andrey I. in A.D. 1156. In the middle of the fifteenth century, Ivan Vassiliwitz, Duke of Muscovy, recovered his independence, and having subdued a number of petty chieftains, and added the duchies of Tver and Novgorod to his dominions, assumed the title of Grand-duke. His grandson, of the same name, subdued the Tartar kingdoms of Kazan and Astrakhan, and assumed the title of Czar or Great King. In 1598 the race of Ruric became extinct; and after a period of anarchy, Michael Romanoff, the grandson, by the mother's side, of the last czar, was raised to the throne of the czars in 1613. His grandson, Peter Alexowitz, reformed the institutions of his empire, beat the Swedes and the Turks, acquired a footing on the Black Sea and the Baltic, founded St Petersburg, and assumed the titles of Emperor and Autocrator. With his grandson, Peter II., the male line of the family of Romanoff became extinct; but in 1763 the founder of the existing German dynasty, Charles Peter Ulric, Duke of Holstein-Gottorp, having been adopted as her successor by his aunt the Empress Elizabeth, a daughter of Peter the Great, he mounted the throne as Peter III., and the present Czar (Alexander II.) is his great-grandson.

During the last three centuries the successive dukes and czars of Muscovy and emperors of all the Russias, have followed the same policy of extending their dominions by every possible means, fair or foul. They have now declared themselves the heads and protectors of all the Slavonic races, and of the orthodox Greek Church, and seem to make no secret of their deep-laid project of unscrupulous aggrandizement. Their vast dominion now extends in length through 202° of longitude, and in breadth through 38° of latitude, and is supposed to contain about 65,000,000 of inhabitants, of whom five-sixths are in Europe.

Spain and Portugal. Spain and Portugal, though they be two distinct and separately independent kingdoms, form nevertheless only one geographical region, emphatically called "the Peninsula." The country, above the maritime lowlands, generally consists of high valleys and table-lands, separated by long ranges of rugged mountains, which extend in an easterly and westerly direction, and terminate with promontories in the Atlantic Ocean, while they are connected in the east by their diverging offshoots. The climate and natural productions are consequently very various. The maritime lowlands on the Mediterranean, and the south-western portion of the Atlantic shores, are almost tropical in respect of climate and vegetable productions; but the temperature of the inland regions is cool and mild, and generally dry, though the extremes of summer and winter are excessive. At Madrid, for example, the summer heat is always so great that, according to the Spanish proverb, that city has "nine months of winter and three of hell!" In addition to silk, tobacco, vines, olives, and all the productions of France and Germany, the peninsula produces the orange, citron, sugar-cane, cork-tree, dates, figs, and cotton. Wheat is the grain most generally cultivated; barley and rye are next in quantity; considerable quantities of maize and rice are also raised, but little of oats and potatoes. Wine, brandy, and wool are the principal and most valuable articles of export. Both kingdoms, however, are in a very low estate, in respect of material, commercial, and social well-being. Since 1807 they have been undergoing continual political changes and revolutions, which seem not yet to have reached their consummation, though Portugal is somewhat more settled than Spain. In such circumstances their political importance is almost null, and, in relation to the vast natural resources of the country, the population is very small.

Italy. The Italian peninsula possesses a remarkably well defined boundary, not merely in its long line of sea coasts, but also in the Alps, which separate its northern provinces from France, Switzerland, and Germany; not forming, however, such an impassable frontier as to have saved the country from the invasion and domination of the northern races. In the north, the Alps and the Apennines inclose between them the rich plains of Lombardy, drained by the Po and its numerous tributaries. Further south, the peninsula consists of a long hill country traversed by the Apennines, and bordered by maritime valleys and plains, which are generally more extensive towards the Tuscan than towards the Adriatic Sea. The south-western portions of Tuscany and the Roman State, called the Maremma, are rendered almost uninhabitable in summer by the prevalence of *malaria*. They are likewise marshy, and in consequence left almost uncultivated; they feed nevertheless large herds of beeves and buffaloes. The climate of Italy is humid and not generally salubrious, for while the northern regions are exposed to frequent piercingly-cold blasts from the snow-capped mountains, the southern provinces are oppressed by sultry winds that seem to blow from the African deserts, and are often loaded with an impalpable dust. The natural productions are, however, rich and various. Everything that grows in France and Spain grows at least equally well in Italy, and the people of the northern provinces, especially Lombardy, are sufficiently industrious. The country has long been divided among a number of petty princes, and oppressed by the heavy weight of both spiritual and political despotism. The people, nevertheless, by their talent and industry, have kept their country in a relatively more respectable position than those of the Spanish peninsula; and the example set by the introduction of liberal principles and practices in the states of the King of Sardinia is not likely to remain long without effect on the other states. The people of Italy, however, have never shown such national sympathies as would seem to lead them to coalesce into a great nation, occupying the whole peninsula as one independent country.

Turkey and Greece. The south-eastern peninsula of Europe is occupied by Turkey and Greece, both of which may be described as mountainous countries, including within their ridges numerous fertile valleys, and in some places extensive lowland plains. The climate and productions of the country are generally the same as those of Italy. The two governments that possess it are equally inefficient for good, though the one be that of a great and powerful empire apparently in the last stage of decay, and the other a newly established kingdom. The dominant people of Turkey are the Osmanlee or Ottoman Turks, a branch of the great Toorkee family of Central Asia. There are, however, various other races, some of them more numerous than the Turks, as the Roumi or Greeks, Arnauts or Albanians, Bulgarians, and other Slavonians, Vallachians, Armenians, Jews, Gypsies, and Franks. Greece is now possessed almost exclusively by a people who boast of their descent from the ancient Hellenes, and speak a language not very much altered from the classic form; but they are not the less evidently much mixed with Slavonic and other barbarian blood. Their independence was established in 1827, but as yet it has been unproductive of any good.

EUROTAS, in *Ancient Geography*, a river of Laconia, which rises in the mountains separating that country from Arcadia, and, after traversing through its whole length the great valley formed by Mount Parnon on the east and Taygetus on the west, falls into the Laconian Gulf. Before it received the name of Eurotas it was known as the Bomycas, and afterwards as the Himerus. Its modern name during the upper part of its course is Iris or Niris; from the town of Sparta to the sea it is known as the Vasilipotamo or King-river.

EURYALUS, a celebrated Trojan, son of Opheltes, celebrated in the *Æneid* for his personal gallantry and his friendship for Nisus the son of Hyrtacus.

EURYDICE, the wife of Orpheus. See ORPHEUS.

EURYMEDON, in *Ancient Geography*, a river of Asia Minor, rising in the mountains of Pisidia, and flowing due south through Pamphylia into the Pamphylian Sea. Its modern name in the upper part of its course is Save-Su; in the lower, Capri-Su. Anciently the Eurymedon was navigable; but its mouth is now closed by sand-bars. Historically it was famous as the scene of a celebrated battle, in which Cimon the son of Miltiades, after destroying the Persian fleet at Cyprus, completely routed their land forces, B.C. 470.

EURYSTHEUS, a king of Argos and Mycenæ. See HERCULES.

EUSEBIUS, surnamed PAMPHILI, bishop of Cæsarea, the father of ecclesiastical history, was born about the year 264 A.D., towards the close of the reign of the Emperor Gallienus. Of his youth nothing is known except that he was a most assiduous student, and probably held some inferior office in the Cæsarean church. In the persecution set on foot against the Christians by Diocletian, Pamphilus, the bishop of that church, was imprisoned, and after two years' confinement suffered martyrdom. During the whole of this period he was tended with the most watchful care by Eusebius, who testified his affection for the old bishop among other ways by assuming his name. When all was over, Eusebius fled to Tyre, where he was kindly treated; and afterwards to Egypt, where he was thrown into prison. On procuring his release he returned to his native Cæsarea, of which he was appointed bishop about the year 315. In the year 325 Eusebius attended the Council of Nice, and was appointed to deliver the address to the Emperor Constantine, and then to take his seat on his right hand. He took a leading share in the proceedings of this assembly, as may be inferred from the fact that he drew up the first draught of the Nicene Creed. The position of the Church at the time this council was convoked to deliberate upon it was embarrassed and complicated by the rise and spread of the Arian heresy, which, from certain inconsistent and self-contradictory passages in his previous works, Eusebius was believed to favour. His real views of the relation between the first two persons of the Trinity appear, so far as he has developed them, to coincide pretty much with those of Origen; but he neither went fully into the subject himself nor encouraged its discussion in others, believing it to lie beyond the pale of human cognizance. With this idea, he appeared at the Nicene Council disposed to regard the case of Arius with the utmost tolerance, and not only so, but he even wrote a letter to Alexander of Alexandria, whose object was to vindicate the orthodoxy of Arius from his own writings, or, in the event of the worst, to save him from punishment for maintaining a doctrine to which, in his estimation, far too much importance was attached. Accordingly the draught of the creed which he prepared, and which was sanctioned by a moderate party in the council, was calculated to meet the views both of the Arian section of the assembly and their antagonists, whose most redoubtable champion was Athanasius. Arius accepted the creed as subsequently modified by the majority of the council, with the addition of the word *consubstantial*, on which Athanasius vehemently insisted. Eusebius at first refused to sign the draught of the creed as thus modified; but on the representations of Constantine agreed to do so, explaining, in a circular to his diocese, the grounds on which he did so. The deposition of Arius he strongly opposed, and, contrary to the opinion of Athanasius, used his efforts to have that heretic reinstated in his charge. Nor did he abate his intimacy with the chiefs of the Arian party in the church. One of its chief defenders was his own namesake, the bishop of Nicomedia. The sect which took its name from this prelate, and of which Eusebius Pamphili was a distinguished member, appears to have been actuated more by hostility to Athanasius than a desire to promulgate the tenets of Arius, who had himself submitted to the decrees of the Council of Nicæa. In the Council of Tyre, Eusebius joined in the outcry against Athanasius, who was deposed for alleged disobedience to the emperor, disrespect to the council, &c.; and he even seems to have used his influence with Constantine to secure the banishment of that father. Some of the personal traits in the character of Eusebius are interesting. He had an intense hatred of the pictures and images of Christ, the use of which were then beginning to creep into the church; and on one occasion, when requested by the sister of Constantine to send her one of the pictures in question, he not only refused, but denounced in the strongest language the use of such adjuncts of worship, as savouring of heathenism. Another point on which he held equally strong opinions was the impropriety of transferring ecclesiastical officers from one sphere of labour to another, and exemplified the sincerity of his convictions on this point by refusing the see of Antioch, which he was repeatedly pressed to exchange for his own. His modesty was duly appreciated by his imperial patron, who declared Eusebius worthy to be bishop of the whole world. Eusebius died about the year 340, at the age of seventy-six. Apart from the many strictures which subsequent writers have passed upon the orthodoxy of Eusebius, his fidelity as an historian has been impugned by Gibbon, who describes Eusebius himself as a mean sycophant, living on the breath of his imperial patron. The charge of sycophancy is one to which Eusebius is obnoxious in common with nearly the whole Christian world of that time. Under Constantine the Christians were not only secured against the persecutions to which they had hitherto been exposed, but had the satisfaction of seeing their religion established as that of the state. It is no wonder, then, that they should have been rather extravagant in demonstrating their gratitude for so remarkable a change, and ascribing to Constantine praises which were not the right of any mortal. The graver charge of historical infidelity is one which has been alleged against Eusebius by Gibbon alone, and is based only on a confession of the historian himself, that in his account of the early Christian church he suppressed allusion to the strifes and dissensions which occasionally broke out; believing the narration of such incidents less edifying than the stories of the martyrs whose lives and deaths were alike honourable to themselves and the religion they professed. From his avowed adoption of this principle, his history may be defective, but it is not therefore necessarily dishonest.

Of Eusebius' works the most important are the following:—

1. The *Ecclesiastical History*, in ten books; comprising the history of the church from the ascension of Christ to the defeat and death of Licinius, A.D. 324. 2. The *Chronicon*, in two books; comprising a historical sketch, with chronological tables, of the most important events in the history of the world from the days of Abraham till the twentieth year of the reign of Constantine. This work, which is one of great importance in the study of ancient history, was published in its complete form for the first time by Mai and Zohrab at Milan in 1818. 3. The *Præparatio Evangelica*, in fifteen books; a collection of facts and quotations from the works of nearly all the philosophers of antiquity, intended to prepare the reader's mind for the acceptance of the Christian evidences. 4. The *Demonstratio Evangelica*, a learned and valuable treatise on the evidences them-

selves. 5. An essay *Against Hierocles*, at whose instigation Diocletian had persecuted the Christians. 6. *De Martyribus Palestinæ*, a history of the persecutions under Diocletian and Maximin from 303 to 310. 7. *Against Marcellus*, bishop of Ancyra, who had been condemned for Sabellianism. 8. *De Ecclesiastica Theologia*, a continuation of the last-mentioned essay. 9. *De Vita Constantini*, a panegyric on that emperor. 10. *Onomasticon de locis Hebraicis*, a treatise on the geography of the Bible.

(Cave, *Script. Eccl. Hist. Lit.*; Fabric. *Bib. Græc.*; Neander; Waddington's *History of the Church*; Smith's *Dictionary of Gr. and Rom. Ant.*; *Biogr. Univers.*, &c. &c.)

EUSTACHIUS (in Italian Bartolomeo Eustachi), one of the most celebrated anatomists of the sixteenth century, of whose history almost nothing is known except that he died at Rome in 1570. His name is preserved in that of the Eustachian tube, which runs between the inner ear and the upper part of the throat; and the Eustachian valve of the heart. See Anatomy, vol. iii., p. 46.

EUSTATHIUS, bishop of Berœa, was a native of Side in Pamphylia. By the council of Nice, in which he distinguished himself by his zeal against the Arians, he was promoted to the patriarchate of Antioch. So violent was the feeling among the Arians against him, that a synod of Arian prelates convened at Antioch brought about his deposition and banishment through a series of heavy charges founded on evidence which they themselves knew to be false. This villany was not discovered till a woman, whose evidence had told very heavily against Eustathius, confessed on her deathbed her own perjury, and that of the other witnesses, who had been suborned. Her confession came too late to benefit the deposed bishop, who had died at Trajanopolis in Thrace, A.D. 329 or 330. Of several works attributed to Eustathius there is only one which can with certainty be pronounced his—an address, namely, to the Emperor Constantine, during the sitting of the council of Nice.

Eustathius, archbishop of Thessalonica, was a native of Constantinople, and flourished during the latter half of the twelfth century. Such of his works as have descended to our times display a comprehensiveness and variety of erudition that fairly entitle him to the praise of being the most learned man of his day. The most important of these is his *Commentary on the Iliad and Odyssey of Homer*, a work valuable as comprising large extracts from the scholiæ of other critics whose works have now perished, such as Apion, Heliodorus, Aristarchus, Aristophanes of Byzantium, &c. This commentary was first published at Rome, 1542–50, in 4 vols., and was reprinted at Leipzig in 1825–29, under the editorial care of G. Stalbaum. Eustathius also wrote a Commentary on Dionysius the Geographer, first printed by Robert Stephens in 1547, and frequently reprinted since. A Commentary on Pindar, which he is known to have written, has been lost. Eustathius died in 1198. The funeral orations pronounced in his honour by Euthynius and Michael Choniates are still in MS. in the Bodleian Library.

Eustathius, a famous Græco-Roman jurist, who flourished at Constantinople in the latter half of the tenth century, and filled various high offices under the emperors who reigned during that period. He is frequently mentioned under the names of Patricius, Magister, and Romanus. Besides his *Romaïca*, frequently quoted by later jurists, Eustathius wrote a number of other works never published, the MSS. of which are still extant in the Vatican at Rome, in Paris, and elsewhere.

EUSTATIUS, St, one of the Leeward Islands, in the West Indies, between Saba and St Christopher's, 15 miles from the former, and 8 from the latter. N. Lat. 17. 31.; W. Long. 63. 3. It is a high rock, rising from the waves in the form of a pyramid, and is 29 miles in circumference. The climate is healthy, and the soil, which is cultivated to the very summit, most prolific. Like other islands in this region of the globe, St Eustatius is subject to the desolating visitation of thunder-storms and hurricanes. The latter

are most to be dreaded during August and September. There is only one landing-place, which, besides being difficult of access, is strongly fortified; a precaution which has been taken with every assailable point in the island. Besides growing sugar, cotton, maize, and large quantities of tobacco, the inhabitants rear great quantities of the smaller kinds of live-stock, in which they carry on a considerable contraband trade with the neighbouring islands. St Eustatius was settled by the Dutch as early as the beginning of the seventeenth century; but in 1665 it was taken by the British, who in their turn were ejected by the French. In 1781 it yielded to Admiral Rodney, but was again wrested from the English by the French; and, after repeatedly changing masters according to the varying fortunes of war, it was finally transferred to the Dutch government at the peace of 1814. Pop. about 3000.

EUSTYLE. See Glossary to Architecture.

EUTERPE, one of the nine muses, who was supposed to preside over lyric poetry and playing on the flute, the invention of which instrument is ascribed to her. The name is derived from εὖ *well* and τέρπω *I delight;* hence Euterpe signifies the inspirer of pleasure. This goddess is usually represented as a virgin crowned with flowers, and holding a flute; or with various musical instruments lying around her. To Euterpe has also been ascribed the invention of tragedy, which, however, is more usually attributed to her sister Melpomene.

EUTIN, the capital of the principality of Lubeck, grand duchy of Oldenburg, 20 miles N.N.W. of the town of Lubeck. It is pleasantly situated on a lake of the same name, in a detached territory surrounded by Holstein; and has a handsome ducal palace and park, and about 3000 inhabitants.

EUTROPIUS, a Roman historian, whose surname is conjectured by Sigonius, though on no reasonable grounds, to have been Flavius. So little has been ascertained concerning his personal history, that it is not even known to what country he belonged. He held the office of secretary (*epistolaris*) under Constantine the Great, accompanied Julian in his unfortunate expedition against the Parthians, and survived to the reign of Valens, to whom he dedicated his history. This work, published under the title of *Breviarium Historiæ Romanæ*, is a compend of Roman history from the foundation of the city to the accession of Valens. This treatise has been compiled with considerable care from the best accessible authorities, but every incident discreditable to the Roman name has been either wholly omitted or quietly glossed over. Modern criticism, too, has not failed to discover occasional mistakes both in matters of fact and in the chronology; and though the style is clear, simple, and precise, and evidently framed with great care on the models of the Augustan age, yet sometimes words are used belonging rather to the silver than the golden age of Latin literature. From its brevity and clearness, Eutropius' history was for a long time a favourite elementary school book; and it is not yet wholly superseded. As a history its value is not great, but it is sometimes serviceable in supplying the lacunæ occurring in history from the total loss of some of the classics, and the imperfect state in which others have come down to us. There have been many editions of Eutropius. That by Havercamp was reputed the best till the appearance of the more complete and critical ones by Tzschucke, Leipz. 1798, and Grosse, Halle, 1813. Of the two Greek translations of Eutropius, that by Capito Lycius has long since perished; the more recent version ot Pæanius will be found incorporated with the best editions of the Latin text.

EUTYCHES, the founder of the heretical sect of the Eutychians, was a presbyter and abbot at Constantinople, and first came into notice at the time of the Nestorian controversy. Nestorius (though he disavowed the charge) was

accused of teaching "that the divine nature was not incarnated in, but only attendant on, Jesus; being superadded to his human nature after the latter was completely formed." Eutyches, in the zeal of his opposition to this doctrine, went to the opposite extreme, declaring that in Christ there was only one nature, that of the incarnate Word, and that his human had been absorbed by his divine nature. A council, convened at Constantinople in 448 (the year in which this heresy was broached) condemned Eutyches, who appealed to a general council called in 449 by the Emperor Theodosius at Ephesus. The scenes of shameful violence with which this council was disgraced gained for it the title of "the synod of robbers." Eutyches was acquitted; his opponents sought safety in flight; and Flavianus, bishop of Constantinople, was scourged by the soldiers who had been stationed in the hall to keep order. On the death of Theodosius, his successor, Marcian, convoked a council at Chalcedon (the fourth œcumenical council of the Latin Church), which annulled the proceedings of the Ephesian assembly, condemned the heresy of Eutyches, and degraded him from the priestly office. Eutyches is believed to have died in exile. The Eutychian heresy was kept alive and fostered by Eudocia, the widow of Theodosius, and sometimes broke out in scenes of violence that required to be checked by an armed force. Under the title of Monophysites the disciples of Eutyches continued to propagate their doctrines, though with no remarkable success, till the sixth century, when Jacob Baradæus (who died bishop of Edessa in 588) gave a powerful impetus to their extension. Under the name of Jacobites the Eutychians constitute at this moment a very numerous church, whose principal adherents lie among the Copts and Armenians. See MONOPHYSITES and MONOTHELITES.

EUXINE, the English form of the Latin Euxinus, the classical name of the Black Sea. The original designation of the sea was *Axenus* or Inhospitable, from the fierceness of the storms with which it was believed to be periodically visited, and also from the ferocity of the nations which dwelt around its shores. By the later Greeks its name was changed into *Euxinus* or Hospitable, as being a word of better omen.

EVAGRIUS, surnamed SCHOLASTICUS and EX-PREFECTUS, was born at Epiphania in Syria, A.D. 536. From his surname he is known to have been an advocate, and it is supposed that he practised at Antioch. He was the legal adviser of Gregory, patriarch of that city; and through this connection he was brought under the notice of the Emperor Tiberius, who honoured him with the rank of quæstorian. His influence and reputation was so considerable that, on the occasion of his second marriage, a public festival was celebrated in his honour, which, however, was interrupted by a terrible earthquake, said to have destroyed 60,000 persons. Evagrius' name has been preserved by his Ecclesiastical History, extending over the period from the third general council (that of Ephesus, A.D. 431) to the year 594. Though not wholly trustworthy, this work is tolerably impartial, and appears to have been compiled from original documents, though it is disfigured by the unquestioning credulity characteristic of the age. The best edition is that contained in Reading's *Greek Ecclesiastical Historians*, Cambridge, 1720. It is also translated in Bagster's work bearing the same title.

EVANDER, in *Greek and Roman Mythology*, a son of Mercury and an Arcadian nymph called in the Greek traditions Themis or Nicostrate, and in the Roman Tiburtis, or more commonly Carmente. In consequence of civil broils, in the course of which Evander was worsted, he left his native city of Pallantium in Arcadia, and sailed for Italy, where he settled at the foot of the Palatine Hill, and was hospitably received by king Turnus. The town of Pallantium, which he is said to have built on the spot where he disembarked, was subsequently incorporated with Rome, and gave name to the Palatine Hill, Palatium, &c. Among the other arts which traditions describe him as diffusing among the Italians, was that of writing, which he had himself learned from Hercules. Virgil describes Evander as still alive when Æneas landed in Italy, and as forming an alliance with that chief against the Rutuli.

EVANGELISTS (from εὐ *well*, and αγγελος *messenger*, or messenger of good tidings). This term is applied in the New Testament to a certain class of Christian teachers who were not fixed to any particular spot, but travelled either independently, or under the direction of the Apostles, for the purpose of propagating the gospel. In the Epistle to the Ephesians (iv. 11) the *Evangelists* are expressly distinguished from the pastors and teachers, who were persons stationed at particular places to confirm and instruct the converts statedly and permanently. Such is the representation given by Eusebius (*Hist. Eccles.*, iii. 37). Referring to the state of the church in the time of Trajan, he says, "Many of the disciples of that time, whose souls the Divine word had inspired with an ardent love of philosophy, first fulfilled our Saviour's precept by distributing their substance among the poor. Then travelling abroad they performed the work of evangelists, being ambitious to preach Christ, and deliver the scripture of the Divine Gospels. Having laid the foundations of the faith in foreign nations, they appointed other pastors, to whom they entrusted the cultivation of the parts they had recently occupied, while they proceeded to other countries and nations." The term evangelist is also applied in a more limited sense to the authors of the canonical Gospels.

EVAPORATION is that process by which liquids and solids gradually assume the gaseous form, or by which, in certain circumstances, an invisible vapour or gas is continually detached from the surface of water, and perhaps of every other liquid, as also from the surfaces of many, if not every solid. From this process being generally found to lower the temperature of the evaporating body, an effect which might have been expected from the doctrine of latent heat, it is probable that heat enters largely into the constitution of every vapour, and is therefore supposed to be the principal agent. At a given temperature, a cubic foot or other determinate space incumbent over a liquid, cannot contain above a certain quantity of the same kind of vapour; and when it contains that maximum, it is said to be saturated. If, therefore, after this is the case, any additional vapour continue to be thrown off, it must either fall back immediately into the liquid, or, if slightly cooled, may apparently remain suspended in the visible form of a cloud, which, however, is not properly vapour, but minute drops, formed by the cooling of it, and which successively fall back into the liquid. For evaporation continues to go on under the pressure of air or other gas however dense; but ceases in the presence of any gas, however rare, if already saturated with the same vapour, unless such gas be colder than the evaporating body; in which case, however, the vapour being partly condensed into drops, becomes cloudy, as was just mentioned; and sometimes liquids, while in the act of ebullition, which is rather an extreme case of evaporation, throw up small drops, which may be seen alternately rising and falling in the vapour. Such is a summary of a few of the leading facts, several of which we shall have occasion to touch on more fully, along with other particulars, whilst briefly noticing, as we shall now do, some steps in the history of this inquiry, before proceeding farther.

Historical sketch of various theories of evaporation.

The spontaneous disappearance of water, and the drying of humid bodies, or the tendency which moisture has to escape from them and diffuse itself in the atmosphere, and afterwards to descend as rain, snow, dew, &c., must have been familiar to mankind in every age, condition, or climate; but anything like an approach to a rational expla-

Evaporation.

nation of the facts seems to be of very modern date. Some of the ancients, particularly Aristotle, conjectured that fire was concerned in the process; but such of their notions as have come down to us are so little to the purpose, that they need not now be dwelt upon. Halley supposed that aqueous vapour consisted of small hollow spherules, filled with something so very light, that they readily ascended and floated in the air,—a theory not altogether such as might have been expected from the known sagacity of its author; for, though Descartes seems to have hinted at the same thing long before, it scarcely appears to have had the least shade of truth in it. But so completely was Kratzenstein's imagination filled with this doctrine, that he fancied he could see these vesicles with a microscope, and even discern them to be hollow, notwithstanding their being supposed to form a transparent vapour. If he really saw any thing, it was more probably minute drops of water descending in the air. Nay, almost up to the close of the last century, we find many eminent men, and among these the late able mathematician Mr George Atwood, maintaining and speculating on this vesicular theory, as it was called. Halley, it is true, hinted at another theory, which not a few embraced, and for which some have still a predilection, namely, that air holds moisture united to it by chemical solution or affinity; but the first idea of this seems to be due to Hooke. A different explanation was attempted by Desaguliers, who, after pointing out the defects of former theories, showed that water is capable of being converted into a transparent elastic fluid, which he supposed to be many times lighter than air, and that it could therefore ascend and float in the atmosphere; but he some time afterwards inclined to ascribe the ascent of vapour to an electrical attraction of the air. Desaguliers was no doubt greatly mistaken regarding the specific gravity of steam, which, under the same pressure and temperature, is now known only to fall short of that of air in the ratio of five to eight; but he was perhaps the first who thought of identifying pure steam with the attenuated aqueous vapour diffused in the atmosphere. It would seem that prior to Desaguliers advancing this notion, it was not known that steam is always generated in a transparent state, although minute drops of water may be passing or falling through it; and indeed some are scarcely aware of this at the present day. The fact is, that steam or aqueous vapour preserves its transparency so long as it has neither lost heat nor had its volume enlarged; but so soon as its temperature is lowered, whether from losing heat or from enlargement of volume, it is more or less condensed into minute drops of water, which of course render it opaque. For we can on no account admit the very generally received doctrine of M. Clement, that equal weights of steam, if in contact with water, contain equal quantities of heat, whatever be their volumes or temperatures. On the contrary, we cannot help believing that a given weight of steam requires more heat to maintain it in the transparent elastic form, when under a greater volume, than under a less; and in proof of this, we presume it is only necessary to adduce the following fact. If we open a stop-cock in the cover of a boiler when the pressure is only one atmosphere, the steam which issues preserves its transparency till it get to some distance from the orifice; but when the pressure within amounts to two or three atmospheres, the steam, if allowed to issue freely, is opaque from the very orifice. This clearly shows that the same quantity of heat (we do not mean temperature) which had been amply sufficient to maintain the steam in the transparent form under a smaller volume within the boiler, is quite inadequate to do so when the steam is allowed to enlarge its volume under a reduced pressure. A more palpable or satisfactory proof than this, which has been long before the public, is scarcely to be wished; yet we find Dr Lardner subsequently reading a paper to the Royal Society on the heat of steam, and which has for its foundation the untenable theory of Clement. Indeed M. Clement's mode of experimenting was so fallacious, that it would have given him the same results whether his theory had been true or not. For when the stream of steam is very small, and of course passes through the stop-cock with difficulty, as it must have done in his experiments, it has, while in the act of dilating from under a force of two or three to that of one atmosphere, the opportunity of absorbing heat from the metal of the scarcely open stop-cock, then much hotter than 212°, the temperature to which the dilating is supposed to reduce the steam. No wonder then that equal weights of steam, at first so different in density, should, when received in equal quantities of cold water, produce equal rises of temperature; as is pointed out more particularly in the *Philosophical Magazine* for July 1826, p. 38. It is likewise to be remembered, that though in the other experiment the steam must have been absorbing some little heat from the stop-cock, this did not enable it to preserve the transparent form. We have been the more particular in clearing up this point, because we shall shortly have occasion to refer to it.

Desaguliers's theory.

Doubts regarding Clement's theory of the latent heat in vapour.

From the time of Halley and Desaguliers to about 1770, a variety of essays on evaporation made their appearance, which, however, tended but little towards elucidating the subject, because they were either not founded on experiments at all, or on such as were not sufficiently elementary. Some of these sought to establish the vesicular system, while others advocated that of chemical solution and electrical attraction. At length, in 1783, came forth the well known *Essais sur l'Hygrométrie* of M. de Saussure, who, though he did not labour so much to establish new theories as to blend together or combine some of those already mentioned, certainly added considerably to the stock of facts. But he at the same time greatly indulged his fancy in supposing aqueous vapour to be capable of existing in four different forms. When it alone occupied a space, he called it *pure elastic vapour*; when diffused in a transparent state in the air, he named it *dissolved elastic vapour*, imagining it to be chemically dissolved by the air; but after the air was quite saturated with this sort, he thought some of it assumed the form of *vesicular vapour*, only differing from that of Halley in being visible. To these he added *concrete vapour*, which consisted of liquid drops, such as form clouds and fogs; a real form of moisture to be sure, but one which is not properly vapour at all. In these *Essais* we have an account of a variety of experiments, most of them having the advantage of being executed on a great scale; but, on the other hand, they were often deficient in that elementary simplicity which is so important in a research of this nature, if we would avoid sources of fallacy. By inclosing a known weight of caustic alkali in a very large glass balloon, previously filled with thoroughly damp air, Saussure endeavoured to find what quantity of moisture this air contained, from the increase of weight which it communicated to the alkali; and conversely, by weighing a bit of wet linen, and suspending it in the balloon filled with dry air, he estimated how much moisture had evaporated from the linen to render the air thoroughly damp. These two methods not only gave him nearly the same result, but did so whether he used pure hydrogen or carbonic acid in the balloon, and even when he employed a mixture of these gases. During these experiments he also observed, by means of a gauge, what change of pressure took place within the balloon from the change of humidity.

Researches of Saussure.

By operating at different temperatures, he obtained re-

sults from which different conclusions might be drawn to suit different theories; for instance, that the quantity of vapour which could exist in the balloon varied in geometrical progression for equal intervals of temperature, and nearly as the square root of the air's density; and that air of the ordinary density could contain five times as much vapour as a vacuum did; all of which conclusions are now known to be incorrect. Prior to this, Lambert had, from his experiments, drawn a very different but still more erroneous conclusion, that the quantity of moisture varied as the *square* of the air's density.

Theory of Deluc and Dalton.

It was natural to think that the great discordance between the results of these celebrated philosophers should have raised doubts whether they might not both have deceived themselves by too complex a mode of operating, and, therefore, that neither of them was likely to be correct. Accordingly we find M. Deluc, in his *Idées sur la Météorologie*, hinting at an incomparably more simple theory, which he afterwards developed more fully in the *Philosophical Transactions* for 1792, viz. that the quantity of vapour which can exist in a given space depends upon the temperature alone, and is independent of the presence or density of air, or of any other elastic fluid with which the vapour forms no chemical combination, being the same as if nothing but the vapour occupied that space. In this speculation he also maintained, as Desaguliers had done, that pure steam and the attenuated aqueous vapour diffused in the air are the same. Something similar to this theory was advanced by M. Pictet in his *Essai sur le Feu*, and still more so by Dr Dalton in his *Meteorological Essays*; and it is not improbable that each might have hit upon the same theory before knowing what the others had done. By inclosing his hygrometer along with a little water under a receiver, Deluc found that the indications of that instrument were the same whatever was the density of the included air, or however much he exhausted it; and the same thing held true with other gases. Volta, likewise, from a great variety of experiments, was led to acquiesce in the theory of Deluc.

Dr Dalton's researches.

The theory was farther investigated, in a much more elementary way, by Dr Dalton, as detailed in the *Manchester Memoirs*, vol. v.; but preparatory to noticing it, we shall subjoin his manner of expressing himself on the subject in his *Essays*, p. 201, where, from certain experiments and observations, he infers "that the vapour of water, and probably of most other liquids, exists at all temperatures in the atmosphere, and is capable of bearing any known degree of cold without a total condensation, and that the vapour so existing is one and the same thing as *steam* or vapour of 212° or upwards. The idea, therefore, that vapour cannot exist in the open atmosphere at a lower temperature than 212°, unless chemically combined therewith, I consider as erroneous; it has taken its rise from a supposition that *air* pressing upon vapour condenses the vapour equally with *vapour* pressing upon vapour; a supposition we have no right to assume, and which, I apprehend, will plainly appear to be contradictory to reason and unwarranted by facts; for when a particle of vapour exists between two particles of air, let their equal and opposite pressures upon it be what they may, they cannot bring it nearer to another particle of vapour, without which no condensation can take place, all other circumstances being the same; and it has never been proved that the vapour in a receiver from which the air has been exhausted is precipitated upon the admission of perfectly dry air. Hence, then, we conclude, till the contrary can be proved, that the condensation of vapour exposed to the common air does not in any manner depend upon the pressure of the air." The method which Dr Dalton took to clear up this question is distinguished by an elegant simplicity. In the *first* place, he determined by experiment the expansive force of dry air for each degree of temperature between 32° and 212°; and was the first who did so with any thing like accuracy. He at same time found that 1000 cubic inches of air at 32° expanded to 1376 on being heated to 212°, which comes surprisingly near 1375, the result published by M. Gay Lussac shortly after. But through some inadvertency Dr Lardner (on Heat, p. 57) makes Dr Dalton's result 1325, and then gravely adds, that "the latter (Gay Lussac's) determination has been proved by subsequent experiments to be the more correct." *Secondly*, Dr Dalton ascertained the force of pure steam in contact with water for each degree throughout the same range; and, *thirdly*, he found at what rate dry air expanded, when put in contact with water, and then heated through the various degrees of that range. The result was, that at any particular temperature, the expansive force of dry air in the first case, added to the force of vapour in the second, was exactly equal to their joint expansive force in the third. From this it is obvious that there is either no chemical combination between the air and vapour, or that such combination, if it exist, is quite inert, or goes for nothing so far as this research is concerned. Dr Dalton found, that when other gases were substituted for air, the vapour gave the same results; and similar results were obtained when other vapours were treated as steam.

Researches of M. Desormes, &c.

M. Desormes, likewise, by operating in a manner very different from that of Dr Dalton, found the quantity of vapour to be independent of the presence of air or other gases. The question was also examined experimentally by M. Gay Lussac, with his well-known accuracy and ability, and his results precisely agreed with those of Dr Dalton. Still more recently Professor Daniell has made a great variety of interesting experiments on mixtures of gases and vapours, in a manner similar to that employed by Deluc, but with the help of an incomparably better hygrometer; and his researches, too, corroborate the theory completely.

Several objections have been made to this theory; but all of them with which we are acquainted are so nugatory and irrelevant that we do not think they require any refutation. There is, however, a point which the foes as well as the friends of the theory have taken for granted, and which, though extremely probable, it would, for any thing we can see, be very difficult to prove in a direct and unexceptionable manner; viz. that the expenditure of heat in forming a given weight of vapour is the same, whether the process take place in air or other gas, or in a vacuum. Since in most combinations heat is given out, it is a wonder that those who contend for the solution of vapours in gases have not founded some objection on this; for we presume it is the only point on which a doubt could be palmed respecting the theory. It is generally taken for granted too, that the expenditure of heat in forming a given weight of vapour is the same at every temperature; but this assumption we cannot help regarding as very erroneous, because to us it appears quite clear that the expense of heat is greater when the vapour is rarer; and this we maintain for the following reason.

Doubts regarding the expenditure of heat being always the same.

The density of steam at 212°, for instance, is about 109 times greater than at 32° Fahrenheit; and we have already seen that steam loses in a considerable degree the elastic form by being dilated to two or three times its bulk; how much more then if dilated 109 times? Hence steam rarefied to such a degree would need a large addition of heat to enable it to maintain the gaseous form; in other words, much more heat must be expended or become latent in forming a given weight of vapour at 32° than at 212°. If steam, when kept separate from water, have its temperature raised by compression at the same rate as air has, it might be shown that the expense of heat in forming vapour at 32° would be to that at 212° as thirteen to eight nearly, that is, in the

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ratio of the logarithms of the number of times the steam is rarer than water. See *Philosophical Magazine* for April 1832, page 246.

Experiments on force of vapour at different temperatures.

Vapours and gases agree in so many of their properties, that there seems no doubt of their being but one and the same form of matter. Thus, so far as has been examined, every vapour, when kept separate from any sensibly evaporating liquid, expands by heat at the same rate as air and other gases do; and, like gases too, it observes the law of Boyle, by having the force at a given temperature proportional to the density. But since the density of a vapour in contact with its generating liquid increases with the temperature, its force, when so situated, increases much more rapidly than that of air or a mere gas does. However, the precise law which connects the temperature with the density or force seems to be as yet unknown.

Dr Dalton's experiments.

Dr Dalton having, as already mentioned, ascertained by experiment the force of aqueous vapour between the temperatures of 32° and 212°, deduced from the results what he considered to be the relation between the force and temperature, and for some time it was supposed that by means of it the force could be had for temperatures beyond both limits of that range. Accordingly on this principle he constructed a table which extended from —40°F. up to 325°; and indeed he was pretty fortunate in the extension below 32°, because the half of it has since been so nearly confirmed by the very accurate experiments of M. Gay Lussac, which were carried down almost to — 20° *cent.* or — 4°F.; but above 212° the supposed law was soon found to give the force too small, and the more so as the temperature is higher. Yet Dr Lardner, in his separate treatise on heat, gives this part of the table expressly as the result of Dalton's "accurate experiments," and not as it really was, a mere extension by means of a formula; nor does he warn us of its erring almost two atmospheres at the upper extremity. It is likewise curious that Dr Lardner, while he notices performances of far less merit, is totally silent respecting the labours of the Committee of the Royal Academy of Sciences at Paris in 1829; though they executed by far the most extensive and accurate experiments that ever were made on steam at high temperatures, as will be found detailed in the *Annales de Chimie* for January 1830. All the English abstracts from this which we have seen are very incorrect. Dr Dalton has more recently published another table of the force of vapour adapted to some of his theoretical views; but from its differing considerably from the results of others, especially those of Gay Lussac, we do not consider it so correct for low temperatures as his first one, part of which is given farther on in this article.

Guy Lussac's experiments.

The method employed by M. Gay Lussac to determine experimentally the force of vapour at low temperatures is particularly commendable; and yet its merits seem to have been very much overlooked, even by those who were engaged in similar researches. It may therefore be useful to give a brief account of it here. Other philosophers had either not carried their experiments below 32° at all, or had mismanaged the matter by allowing water to freeze in the tube in such a manner as to obstruct the free motion of the mercury, and likewise to render its altitude ill defined and difficult to be seen. These inconveniences were dexterously avoided by Gay Lussac, who still employed a barometer tube, but one so much longer than ordinary that a considerable part of it next the sealed end was above the mercury, and a portion of this, being bent to about an angle of 60°, was immersed in a cold mixture along with a thermometer. The consequence of this arrangement was, that neither the mercury nor the small portion of water on its top necessarily required to be cooled down at all; because, however moderate their temperature might be, the force of every portion of the included vapour being in equilibrio with the force of that which touched the coldest part of the tube, was just the same as if the whole vapour had been at the temperature of the freezing mixture. A farther advantage was, that after the apparatus had been allowed to remain for a short time in the state now described, the water entirely disappeared from the top of the mercury, having been transferred by evaporation or distillation to the sealed end of the tube, where it was quickly frozen. By this means the mercury became almost as free from moisture as if none had been in the tube. It is, besides, evident that this method could be carried down, not only to and below the freezing point of mercury, but to any temperature, however low, to which the extremity of the tube could be cooled; and that it is applicable to every sort of vapour which does not act upon mercury. In fine, Gay Lussac having placed a barometer tube filled with dry mercury beside and in the same cistern with the one which contained both mercury and moisture, read off the difference in the heights of their mercurial columns with great precision, by means of a microscope which could be shifted up and down a graduated pillar, and the difference was obviously the force of the vapour. Although mercury evaporates at all temperatures, as appears from a bit of gold-leaf becoming white if long suspended over it in a phial, and from the noxious effects of breathing air which has been for some time in contact with a large surface of mercury, yet the force of its vapour is so very small compared with that of steam, that it could not sensibly affect these experiments. Indeed it seems to be a general law, that the forces of vapours from liquids which have high boiling points, are quite inappreciable at low temperatures.

Researches on the rate of evaporation.

The most important problem connected with the evaporation of water is to determine the rate at which, under certain circumstances, it escapes from a given surface at a particular temperature. Many cases of this problem are still very imperfectly solved.

Dr Halley's experiments.

The experiments of Dr Halley, detailed in No. 189 of the *Philosophical Transactions*, seem to be among the earliest which were employed for this purpose. He found that water salted to the state of sea water, and exposed to a heat equal to that of a summer's day, did, from a circular surface of eight inches diameter, evaporate at the rate of six ounces in twenty-four hours. Hence he concludes, that a square degree of sixty-nine miles will evaporate 33,000,000 tuns in a day; and supposing the Mediterranean to contain 160 square degrees, it would evaporate 5,280,000,000 tuns daily. This quantity he considers sufficient to supply all the rains, springs, dews, rivers, &c. It would however be of little use to rehearse the whole of this speculation, because the data, as we shall afterwards see, were too loose, and the experiment was on too small a scale, for such a comparison.

Water carried in by the current at Gibraltar cannot be all spent by evaporation.

Dr Lardner, in touching on this subject in his treatise on heat, says, that in the Straits of Gibraltar, instead of an outward current, there is a rapid and never-ceasing inward flow of water, and that he is therefore compelled to conclude that the evaporation from the surface of this sea carries off the enormous quantity of water supplied from this and other sources. Such doctrine from so respectable a quarter rather surprises us; since it is quite well known that, besides the inward current, which is principally in the middle of the surface, there are generally outward currents, likewise at the surface, next the coasts, particularly the south one, and most probably also in the immense deep beneath. It has been alleged, but erroneously, that the water sometimes flows outwards even in mid-channel on the surface. Had there been no outward current, the Mediterranean must long ago have become as salt as the brine of the Dead Sea; or rather perhaps have become a rock of salt, as Dr Thomas Young remarked; for, as we shall afterwards see, no common salt or other muriate rises from the sea by evaporation. In

order that the same degree of saltness may continue, the outward currents must just bear away as much salt as the inward current and other sources supply, with the very slight exception of what the wind carries off in the form of spray, water spouts, &c. The waters of the Mediterranean being, as is well known, specifically heavier, especially at a great depth, than those of the Atlantic, will naturally incline to buoy them up, and flow out beneath them in the infathomable depth of the Straits.

Dr Dobson's experiments.

A series of experiments on the evaporation of water at natural temperatures was continued for four years, beginning with 1772, by Dr Dobson, at Liverpool, as detailed in the *Philosophical Transactions*, vol. lxvii. He took a cylindrical vessel twelve inches in diameter, and having nearly filled it with water, exposed it beside his rain-gauge of the same aperture; and by adding or withdrawing water, as occasion required, he kept the surface at nearly the same height. By comparing the total quantities thus added or taken away with the proceeds of the rain-gauge, the amount of evaporation was ascertained. The mean monthly evaporation for the four years was, in January, 1·5 inches; February, 1·77; March, 2·64; April, 3·3; May, 4·34; June, 4·41; July, 5·11; August, 5·01; September, 3·18; October, 2·51; November, 1·51; December, 1·49. In all, 36·78 inches. The mean rain for the same time was 37·48. For a great deal more in this way, and on the evaporation of ice and snow, see Howard's excellent treatise on *The Climate of London.* That ice and snow evaporate, appears from their losing weight, or even disappearing altogether, if long enough exposed to a brisk and dry wind during frost. But sometimes snow is rendered so much colder by radiation than the incumbent still air, that it condenses the vapour of that air into hoar-frost, and by that means augments its own weight or bulk.

Experiments of Dr Dalton and Mr Hoyle.

But the experiments of Dr Dalton and Mr Hoyle, though rather of local application, were no doubt far more accurate for evaporation from the soil. Having got a cylindrical vessel three feet deep and ten inches in diameter, two pipes were joined to it, and turned downwards for the surplus rain-water to run off into bottles; the one pipe being near the bottom, the other an inch from the top. The vessel was filled up for a few inches with gravel and sand, and the remainder with good fresh soil. It was then put into a hole in the ground, and the space around filled up with earth, except on one side, for the convenience of afterwards joining bottles to the pipes, and registering their contents. The earth in the vessel was now saturated with moisture, by pouring in water till some of it escaped from the pipes; and, lastly, the bottles were put to. During the first year the soil was bare at top; but for the next two years it was covered with grass, like any green field. A regular register was kept of the rain-water which ran off through the upper pipe, and also of what sunk down through the earth to the lower pipe. A rain-gauge of the same diameter was kept close by, to register the quantity of rain for any corresponding time.

	Water through the two Pipes. 1796.	1797.	1798.	Mean.	Mean Rains.	Mean Evaporation from Ground.	Mean Evaporation from Water.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
January	1·897	0·680	1·774	1·450	2·458	1·008	1·5
February	1·778	0·918	1·122	1·273	1·801	0·528	2·
March	0·431	0·070	0·335	0·279	0·902	0·623	3·5
April	0·220	0·295	0·180	0·232	1·717	1·485	4·5
May	2·027	2·443	0·010	1·493	4·177	2·684	4·959
June	0·171	0·726	...	0·299	2·483	2·184	6·487
July	0·153	0·025	...	0·059	4·154	4·095	5·628
August	...	...	0·504	0·168	3·554	3·386	6·058
September	...	0 976	...	0·325	3·279	2·954	3·898
October	...	0·680	...	0·227	2·899	2·672	2·351
November	...	1·044	1·594	0·879	2·934	2·055	2·042
December	0·200	3·077	1·878	1·718	3·202	1·484	1·5
	6·877	10·934	7·379	8·402	33·560	25·158	44·4
Rain	30·629	38·791	31·259				
Evap	23·725	27·857	23·862				

From these experiments it appears, 1*st*, That the mean annual quantity of water evaporated in the above circumstances is twenty-five inches of rain, to which if we add five for dew, will give thirty inches of water raised annually: 2*dly*, That the evaporation increases nearly, though not exactly, in the same ratio as the rain; thus 1797 gave most rain, and the greatest evaporation, &c.: 3*dly*, That there is little difference between the evaporation from bare earth of sufficient depth, and that from ground covered with grass. It is however to be observed, that the numbers in the last or right hand column belong to the years 1799, 1800, and 1801; and that on account of accidents with the frost, these numbers are partly conjectural for January, February, March, April, and December. The mean annual evaporation during the same three years from ground covered with grass, exclusive of dew, was 23·5 inches, which falls a little short of that for the other three, which was twenty-five.

But there is reason to suspect that a less depth of soil in the vessel would have allowed more water to escape into the bottles, and *vice versa.* It is therefore in some degree a matter of conjecture that this apparatus indicated the true evaporation from the adjacent fields. Lahire having filled a vessel eight feet deep with soil, and sunk it into the earth, left it there for fifteen years. It had an opening at the bottom for the escape of the water, but never a drop came through. The quantity of rain, to be sure, being less at Paris than at Manchester, will so far account for this.

In such an article as this it might be expected that, in conformity with custom, we should state the mean evaporation for all England, and a number of other principal countries. This however we are unable to do, because we are persuaded that to obtain even an approximate estimate would require experiments, such as those of Dr Dalton from the soil, to be made at least within every square mile of surface. The usual estimates being only derived from

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a vessel with water, as will be noticed more particularly afterwards, afford no measure of evaporation from the soil.

Relation between the temperature and rate of evaporation.

The following relation between the temperature and the rate of evaporation from water, was discovered by Dr Dalton. Having, as above mentioned, determined experimentally the force through a considerable range, he was naturally led to examine whether the quantity of water evaporated in a given time bore any proportion to the force of vapour of the same temperature, and was agreeably surprised to find that they corresponded in every part of the range examined. Thus the forces of vapour at 212°, 180°, 164°, 152°, 144°, and 138°, are equal to 30, 15, 10, 7·5, 6, and 5 inches of mercury respectively; and the grains of water evaporated per minute are in the same ratio. This Dr Dalton considers as quite in conformity with the laws of mechanics; for the atmosphere seems by its inertia to obstruct the diffusion of vapour, which would otherwise be almost instantaneous, as in vacuo; but this obstruction, which is greater as the air is more dense, is overcome in proportion to the force of the vapour. Did the obstruction arise from the weight of the atmosphere, it would prevent any vapour from rising at temperatures lower than 212°; but according to Dr Dalton it is caused by the inertiæ of the particles of air, and is similar to that which water meets with in descending among pebbles.

The theory of evaporation was thus far settled so much the more easily, because the force of vapour already in the open air being very small compared with what is produced from water at high temperatures, did not sensibly affect the results; but Dr Dalton found, that if the theory was to be verified by experiments for low temperatures, regard must be had to the force of vapour already in the atmosphere. For instance, if water of 59° were the subject, the force of vapour at that temperature being a sixtieth of the force at 212°, one might expect the quantity of evaporation to be a sixtieth also; but if it should happen, as it sometimes does in summer, that an aqueous atmosphere to that amount does already exist, the evaporation, in place of a sixtieth, would be nothing at all. On the other hand, if the previously existing vapour were the 120th, corresponding to 39° F., then the effective evaporating force would be the 120th of that from boiling water. In short, Dr Dalton found that the evaporating force must in every case be equal to that at the temperature of the water diminished by that already existing in the air. To find the force of the aqueous atmosphere, Dr Dalton revived the method which had been employed by Leroy long before. He used in summer to take a tall glass jar, and fill it with cold spring water, fresh from the well. If dew was immediately formed on the previously dry outside, he poured the water out, let it stand a little to rise in temperature, wiped dry the outside of the jar, and then poured the water in again. The like process is to be repeated till dew cease to be formed, and at that instant the temperature of the water is to be carefully noted, for the purpose of obtaining, from a table like that which shortly follows, the corresponding force of vapour. Such temperature is called the *dew point*, or the *point of deposition*; because the air, if cooled to it, would be in a state of saturation with moisture, and of course ready to deposit dew, especially on any thing in the least colder than itself. This operation should be performed in the open air, or at an open window, because the air within is generally more humid than without. Spring water in this country being generally within a degree or two of 50°, will mostly answer the purpose during the three hottest months; in other seasons an artificial cold mixture may be used. But Leslie's or Daniell's hygrometer would be still more convenient at all seasons.

To observe the evaporation at atmospheric temperatures, Dr Dalton had two light tin vessels; the one six inches diameter and half an inch deep, the other eight inches diameter and three fourths of an inch deep, and both made to be suspended from a balance. Water being put in one of these and weighed, it was placed in an open window or other exposed situation for ten or fifteen minutes, and again weighed to ascertain the loss from evaporation. The temperature of the water was at same time observed, the force of the aqueous atmosphere ascertained as above, and the velocity of the current of air noticed; for with the same evaporating force, a strong wind, by quickly changing the air in contact with the water, will double the effect produced in still air. From a great variety of experiments made during both winter and summer, and when the evaporating force was strong and weak, even in the case of ice, the results were found perfectly conformable with the theory. The same quantity is evaporated with the same evaporating force thus determined as near as can be judged, whatever be the temperature of the air. Thus, if the dew point be 40° while the air is at 60°, the evaporation is the same as if the dew point were at 60° and the air at 72°; for ·524 — ·263, which is the difference of the forces of vapour at 60° and 40°, is nearly equal to ·770 — ·524, the difference of the forces at 72° and 60°; but two such differences could be had exactly equal by using fractions of degrees of temperature, and interpolating between the other numbers.

The following table exhibits the ratios and quantity ot water evaporated at different temperatures, derived from the preceding theory, and confirmed by experiments. The first column is the temperature; the second the force of vapour; the rest give the number of grains evaporated from a surface six inches in diameter, supposing the air to be previously dry. The third column is calculated on the supposition that at the temperature of 212° the evaporation per minute from the said surface is 120 grains; the fourth, that it is 154 grains; the fifth, 189, according to the strength of the wind; for if the air in contact with the water be continually changed, so that the recently moistened portion may be speedily removed and drier air substituted for it, the process will be proportionably expedited. These columns present the extremes and mean of evaporation likely to be noticed when the process goes on in air of the ordinary density. The effects of different densities will be considered afterwards.

Table of the Force of Evaporation.

Temperature.	Force, Inch.	Evaporating Force in Grains.		
20°	·129	·52	·67	·82
21	·134	·54	·69	·85
22	·139	·56	·71	·88
23	·144	·58	·73	·91
24	·150	·60	·77	·94
25	·156	·62	·79	·97
26	·162	.65	·82	1·02
27	·168	·67	·86	1·05
28	·174	·70	·90	1·10
29	·180	·72	·93	1·13
30	·186	·74	·95	1·17
31	·193	·77	·99	1·21
32	·200	·80	1·03	1·26
33	·207	·83	1·07	1·30
34	·214	·86	1·11	1·35
35	·221	·90	1·14	1·39
36	·229	·92	1·18	1·45
37	·237	·95	1·22	1·49
38	·245	·98	1·26	1·54
39	·254	1·02	1·31	1·60

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Table of the Force of Evaporation continued

Temperature.	Force, Inch.	Evaporating Force in Grains.		
40	·263	1·05	1·35	1·65
41	·273	1·09	1·40	1·71
42	·283	1·13	1·45	1·78
43	·294	1·18	1·51	1·85
44	·305	1·22	1·57	1·92
45	·316	1·26	1·62	1·99
46	·327	1·31	1·68	2·06
47	·339	1·36	1·75	2·13
48	·351	1·40	1·80	2·20
49	·363	1·45	1·86	2·28
50	·375	1·50	1·92	2·36
51	·388	1·55	1·99	2·44
52	·401	1·60	2·06	2·51
53	·415	1·66	2·13	2·61
54	·429	1·71	2·20	2·69
55	·443	1·77	2·28	2·78
56	·458	1·83	2·35	2·88
57	·474	1·90	2·43	2·98
58	·490	1·96	2·52	3·08
59	·507	2·03	2·61	3·19
60	·524	2·10	2·70	3·30
61	·542	2·17	2·79	3·41
62	·560	2·24	2·88	3·52
63	·578	2·31	2·97	3·63
64	·597	2·39	3·07	3·76
65	·616	2·46	3·16	3·87
66	·635	2·54	3·27	3·99
67	·655	2·62	3·37	4·12
68	·676	2·70	3·47	4·24
69	·698	2·79	3·59	4·38
70	·721	2·88	3·70	4·53
71	·745	2·98	3·83	4·68
72	·770	3·08	3·96	4·84
73	·796	3·18	4·09	5·00
74	·823	3·29	4·23	5·17
75	·851	3·40	4·37	5·34
76	·880	3·52	4·52	5·53
77	·910	3·65	4·68	5·72
78	·940	3·76	4·83	5·91
79	·971	3·88	4·99	6·10
80	1·00	4·00	5·14	6·29
81	1·04	4·16	5·35	6·54
82	1·07	4·28	5·50	6·73
83	1·10	4·40	5·66	6·91
84	1·14	4·56	5·86	7·17
85	1·17	4·68	6·07	7·46
212°	30	120	154	189

As an example of the use of the table, let the dew-point be 52°, the temperature of the air 65°, with a moderate breeze, to find the evaporation per minute from a vessel six inches in diameter. The number in the fourth column opposite 52° in the first, is 2·06, and that opposite 65° is 3·16; the difference, 1·1 grain, is the evaporation required. Again, if the evaporation per minute, with a brisk wind, be 1·7 grain, while the air is at 62°; required the weight of the aqueous atmosphere, and the dew-point. In the fifth column the number opposite 62° is 3·52, being the whole evaporating force at that temperature in perfectly dry air, from which 1·7 being deducted, leaves 1·82, which, in the fifth column, is opposite to ·294 inch of mercury in the second, the weight of the column of vapour, and to 43° the temperature or dew-point. That is by using the nearest numbers in the table. Greater exactness may be had by interpolating between them. In this case, for instance, the weight should more correctly be ·290, and the dew-point 42°·6. Such estimates, however, are liable to uncertainty, where any doubt remains respecting the velocity of the wind.

Dr Dalton found that the same theory held with regard to the evaporation of other liquids, and was even more easily verified by experiment in their case than in that of water, on account of the air previously containing little or none of their vapours. In short, the evaporation in their case is similar to that of water in perfectly dry air.

Since vapours, so long as they maintain the gaseous form, expand and contract by change of temperature precisely at the same rate as air does in like circumstances, and since mixtures of air and vapour do the same, it follows, that if at any temperature above the dew-point the pressure of the unconfined air have to that of the vapour in it a certain ratio, it will have the same ratio to it at any other temperature not lower than the dew-point. Hence, because the entire pressure is constant, the force of vapour at the actual temperature of the air is exactly equal its force at the dew-point or temperature at which the air under the original pressure becomes saturated with moisture, and at which all the moisture in it just barely maintains the gaseous form.

Dr Anderson, in giving a table of the weight and force of aqueous vapour *in vacuo* (*Edin. Encyc.* xi. 578), says, it is adapted to a pressure of thirty inches, and that when the barometer differs from thirty, the numbers in the table (none of which denote atmospheres, but grains and inches) must be altered in the same ratio as the pressure. It is difficult to conceive how he could fall into such a palpable mistake. Vapour *in vacuo* being protected from atmospheric pressure, has obviously nothing to do with its changes or amount; and we have already seen that the maximum force and density of vapour in air, as well as *in vacuo*, depend solely on the temperature. Yet Dr Anderson (*ibid.* p. 581) makes the maximum weight of vapour which can exist in a cubic inch of air at a given temperature to be proportional to the barometric pressure, which is remarkable, considering his professed adherence to Dalton's theory. It is farther curious that the doctor, not perceiving that the actual force of vapour in the open air must be exactly equal to its force at the dew-point, gives (on same page) a formula for reducing the one force to the other; and he even takes it for granted that Dr Dalton is in the same error, though the very reverse appears from all his writings, and especially those already quoted.

Influence of the density of air on evaporation.

The rate of evaporation is very different in air of different densities, being greater when the density is less, and *vice versa*. Some experiments on this subject are given by Professor Daniell, in the second and much improved edition of his valuable *Meteorological Essays*, published in 1827, page 493, from which we make the following brief abstract:—Upon the plate of an air pump was placed a flat dish 7·5 inches diameter, containing sulphuric acid, and covered by a receiver which but just passed over it, so that the base of the included air rested everywhere on the acid. In the middle of the dish was a stand supporting a vessel 2·7 inches diameter, and 1·3 deep, which was filled with water to the depth of an inch, and had a delicate thermometer resting on its bottom. The water, having been previously freed from air, was weighed with a very sensible balance, and then exposed to the action of the sulphuric acid. Its temperature was 45°, and the barometer at 30·4 inches. At the end of half an hour it was again weighed, and found to have lost 1·24 grain by evaporation. Having been replaced, and the air rarefied till the gauge stood at 15·2 inches, it was found to have lost in half an

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hour 2·72 grains, and to have had its temperature reduced to 43°. By repeating the process, continually diminishing the pressure one half, the successive losses from evaporation in intervals of half an hour each, were as follow:—

Pressure.	Temperature. Beginning.	End.	Loss, Grains.
30·4	45°	45°	1·24
15·2	45	43	2·87
7·6	45	43	5·49
3·8	45	43	8·80
1·9	45	41	14·80
·95	45	37	24·16
·47	45	31	39·40

When the exhaustion was pushed to the utmost, which was ·07 inch, the evaporation in the half hour was 87·22 grains. During this last experiment the water was frozen in about 8 minutes, while the thermometer under the ice was at 37°. There must, however, be some inadvertency respecting the loss from evaporation in the second experiment; because in the table it is 2·87, and in the account before it only 2·72, which last, we presume, is the more correct of the two.

Before inferring from these experiments the rate of evaporation under different pressures, Mr Daniell applied to the results a correction for the variation of temperature. Taking the evaporation as proportional to the elasticity of the vapour, he estimated the latter from the mean of the temperatures at the beginning and end of each experiment, and calculated the amount for a fixed temperature. This might have been supposed to give a near approximation, were it not evident from the last experiment, that, owing to the bulb of the thermometer not being close at the evaporating surface, it indicated often too high a temperature; but the following table presents the results computed on that principle for the temperature of 45°; and here again we suspect the second number 2·97, being computed from 2·87, is too great.

Pressure.	Grains.
30·4	1·24
15·2	2·97
7·6	5·68
3·8	9·12
1·9	15·92
·95	29·33
·47	50·74
·07	112·32

Notwithstanding the slight irregularity of the series, Mr Daniell thinks we can run no risk in concluding that the amount of evaporation is, *cæteris paribus*, in exact inverse proportion to the elasticity of the incumbent air. But perhaps it would be more correct to say, that, *cæteris paribus*, the rate of evaporation is inversely as the *density* of the air; for that is Dr Dalton's view of the matter, and is equally conformable to these experiments. It may however be observed, that the rate of evaporation in the first case, which is in air of the ordinary density, is much smaller than that given by Dr Dalton; but the process going on in so small a volume of still and confined air, seems a sufficient reason for this.

Cooling influence of evaporation.

It was hinted above, that evaporation tends to lower the temperature of an evaporating surface, by abstracting heat from it for the formation of vapour. For, from the well known fact, that in the formation of aqueous vapour as much heat is absorbed as would raise the temperature of 1000 times its weight of water one degree, it follows, that were it not for the heat derived from surrounding bodies, the vaporization of the 1000th part of a mass of water would lower the temperature of the whole one degree; so that by the time the 100th part had evaporated, the temperature of the whole would have fallen ten degrees. But surrounding bodies, particularly the air, by participating in the cooling effects, supply heat in such a manner to the water, that a limit is soon set to the fall of temperature. Although this cooling influence has been long known in a general way, it is remarkable how few experiments have been made, or, so far as we know, published, to show the extent of cold produced in different circumstances; and still more remarkable, that those few results of different experimenters should differ so widely, as we shall presently see they do. Dr Anderson, in the article *Hygrometry*, in the *Edinburgh Encyclopædia*, gives the following as the results of his experiments on the cold produced by the evaporation of water in air of different densities. For this purpose he placed Leslie's hygrometer, along with a cup of sulphuric acid, under a receiver of the air pump.

Dr Anderson's experiments.

29·6	48°·5	43°·64	4°·86	27°
23·6	48 ·5	42 ·38	6 ·12	34
17·6	48 ·5	40 ·58	7 ·92	44
11·6	48 ·5	37 ·34	11 ·16	62
5·6	48 ·5	32 ·12	16 ·38	91

The first column is the pressure in inches, the second the Fahrenheit temperature of the dry bulb, the third that of the moist, the fourth their difference or the depression, and the fifth the same depression in degrees of Leslie's hygrometer. The third and fourth columns, though not in the original, are obviously obtained from the others, and inserted in degrees of Fahrenheit, for the sake of comparison with those which follow.

In an article on hygrometers and evaporation, in the *Edinburgh Philosophical Journal* for October 1826, Mr Meikle gives the two following series of similar experiments, which were not made with Leslie's hygrometer, but with what was reckoned preferable for the purpose, two common thermometer tubes fitted upon one broad and doubly graduated scale; the one bulb being dry and the other covered with wet linen. The columns respectively denote the same things as the first four in Dr Anderson's.

Mr Meikle's experiments.

29·7	48°·2	36°·6	11°·6
19·4	47 ·3	33 ·2	14 ·1
17·2	47 ·2	32 ·5	14 ·7
13·3	47 ·0	31 ·2	15 ·8
8·8	46 ·4	27 ·2	19 ·2
29·9	60°·6	45°·5	15°·1
20·0	59 ·5	41 ·0	18 ·5
10·0	58 ·9	34 ·1	24 ·8
5·6	58 ·5	28 ·0	30 ·5

All sealed thermometers stand too low when the pressure of the atmosphere is removed from their bulbs. The two just mentioned were found to be each 1°·5 too low in an exhausted receiver. Hence most of the numbers in the second and third columns still require to be more or less corrected for this, according to the degree of exhaustion; but since both thermometers were equally affected, the depressions have nothing to do with it. However, the included air seems to have been really a little cooled from the influence of the cold wet bulb.

We have always been puzzled to account for the extreme smallness of Dr Anderson's depressions in the fourth column. Perhaps he had used very weak sulphuric acid, or too small a surface of it; or he might not be aware that the full effect in a single case is seldom attained in less than half an hour. The pressure and temperature in his first case are nearly the same as in Mr Meikle's; and yet the depression 4°·86 is not half of 11°·6. From many trials we know that the weather is by no means very droughty, if a wet thermometer do not fall more than 4°·86, when only exposed in the open air at 48°·5, without any sulphu-

Evaporation.

ric acid at all. To increase the cold in a wet thermometer, Dr Lardner recommends exposing it to the sun. But whoever takes the trouble of properly trying this, will find that the sun has quite the contrary effect; and therefore the doctor is just in the same delusion, only on a greater scale, when he directs his readers to wrap wine bottles in wet cloth, and expose them to the sun as a source of greater cold! The sun, like the fire, aids evaporation, by supplying heat, which will more or less counteract the cooling effect, and may even raise the temperature; but common sense revolts at the very idea of the heating rays of the sun being a source of cold.

In 1827, Professor Daniell published, in the second edition of his *Essays*, p. 499, a series of experiments on the cooling effects of evaporation, and which, like Mr Meikle's, were made by means of two common thermometers, the one dry and the other moist; but he seems only to have read off to the nearest half degree; and his depressions, though not so deficient as those of Dr Anderson, still lean considerably to the same side. The following are his results, arranged as the preceding:

Mr Daniell's experiments.

30·2	50°	41°	9°
15·1	49	37	12
7·5	49	34	15
3·7	49·5	31·5	18
1·8	49·5	28·5	21
.9	49	24·5	24·5
·4	49	23	26

From repeated experiments we have found that at the temperature of 50°, and under a pressure of about thirty inches, a wet thermometer, when inclosed in a receiver along with a sufficiently large surface of strong sulphuric acid, should fall 12°·1 or 12°·2, in place of 9°, as Mr Daniell has it. The rest of his depressions are still more deficient; but when we attend to the disposition of his apparatus, our surprise rather is that the depressions should be so great as they are. What we particularly object to is his not only inclosing a vessel with water under the receiver, but interposing it directly between the wet bulb and the sulphuric acid. This he did for the purpose of occasionally dipping that bulb in the water; a precaution which was not only unnecessary, but which, by rendering the air moist and obstructing the drying of the bulb, must obviously have rendered the whole of his depressions much smaller than they should have been in perfectly dry air. When Mr Meikle made his experiments, and they were published before those of Mr Daniell, he satisfied himself that if the thermometer was properly covered and moistened at first, no renewal of moisture was necessary. This he ascertained by repeating, in a retrograde order, the different cases when he had just completed a series of these experiments; for on finishing with the case in which the air was most rarefied, he readmitted as much air as just brought back the gauge to the next case, which being repeated, he readmitted more air for the next, and so on, till he had got back over the whole series. In every case, the wet thermometer was found to be as much depressed in the backward process as in the forward, a clear proof that there was no lack of moisture. Neither Dr Anderson nor Professor Daniell say whether they made any allowance for the effects of pressure on the bulbs of their thermometers.

Cold not yet observed in vaporizing turpentine.

Oil of turpentine is well known to evaporate very quickly, but we have as yet failed to detect any cold that it produces, though we do not therefore suppose it forms any exception to the general law. Some liquids, as alcohol, ether, sulphuret of carbon, &c. both evaporate more rapidly than water does, and produce a greater cold; but the expenditure of heat is greater in vaporizing a given weight of water than of any other liquid yet examined; a fact from which it had often been concluded that alcohol could be vaporized with so much less fuel than water, that its vapour would be an economical substitute for steam as a first mover; nay, this had become a standard doctrine in almost every scientific compilation. It however involved a fatal oversight, as was first pointed out by Mr Meikle in the *Philosophical Magazine* for July 1826, p. 41, and afterwards by Mr Ainger in Brande's *Journal of Science* for March 1830; for it is not with equal *weights*, but with equal *volumes* of these vapours, that the comparison falls to be made; and when this is done, the greater rarity of steam puts it on at least an equal footing with alcoholic vapour, so far as regards the economy of heat. In other respects, steam is decidedly preferable; for, independently of the enormous expense of alcohol, the density of its vapour, being about 2·5 times that of steam, would prevent it from moving with the same facility through the pipes, valves, &c.

Supposed economical use of alcohol.

Mode of freezing alcohol.

Perhaps it may not be altogether foreign to our subject to mention, that Mr Hutton froze alcohol by condensing air on it in a strong vessel, which being very much cooled by freezing mixtures, was next suddenly opened, when the dilatation of the air, and the consequently rapid evaporation and re-expansion of the alcohol, absorbed so much heat as induced a cold sufficient to freeze it.

Damp clothes, &c. suppress the perspiration.

The bad effects of damp clothes, beds, &c. are usually ascribed to the cold attending the evaporation of the damp; but since considerable injury often follows where scarcely any cold is felt, we suspect the chief cause lies rather in the moisture suppressing the natural evaporation from the skin. The heavy smell which accompanies most dogs, and the fetid grease upon their hair, show that they perspire in some other shape besides what some suppose the only one from their tongues.

Imperfection in the measures of evaporation.

Various instruments have been employed to measure the rate at which moisture escapes into the atmosphere. We have already alluded to the method of exposing water in a vessel, and noting the loss. The vessel is generally circular, with a roof a little above it to keep off the rain, &c.; and, for greater accuracy, the contents may either be weighed from time to time, or measured in a graduated tube. When the vessel is brim full, the wind is apt to blow some of the water over; and when not full, the water is in some measure sheltered from the drying effects of the wind. The only use of such an instrument or gauge is to give us a very vague idea of the drying power of the air. It affords no measure whatever of the evaporation from the ground; for when the soil is exceedingly parched, and consequently has next to no moisture to give off, the gauge generally shows the greatest evaporation of all. Yet in stating the particulars of the climate of a place, it is usual to mention the amount of evaporation derived most probably from no better source. But it cannot even be a measure of the evaporation from a lake, because in that case the indications of the gauge depend very much on the direction of the wind; for it is obvious that if a previously dry wind traverse an extensive lake before reaching the gauge, it may by that time have become so humid as to show little or no drying power at all upon the gauge. When, on the other hand, the wind passes first over the gauge, its indications are to be suspected of erring in excess, because the farther a wind continues to traverse the surface of a lake, the more will its drying power be impaired, and therefore the average rate of evaporation will be less than at the side next the gauge. For this reason the evaporation from a smaller surface of water is, *cæteris paribus*, greater in proportion to the area than from a larger. Whether any general rule could readily apply to this, we are unable to say. Perhaps something like an approximation to the relation between the area and evaporation in such circum-

Eve || Evelyn.

stances would be had by dividing the area by some root of its mean linear dimension taken in the direction of the wind, and multiplying by a constant. But this would not in the least rectify the indications of the gauge. Since similar objections must obviously attach to all gauges employed for this purpose, it would be of little use to give any farther account of them, or of the registers of evaporation with which many works otherwise valuable are so often encumbered.

No muriatic acid in sea air.

It had been long supposed that muriatic acid vapour existed in the atmosphere incumbent over the ocean or on the sea coasts; and various effects were ascribed to its presence. But from experiments detailed in the *Journal de Pharmacie* for November 1833, it appears that such effects are solely owing to minute drops of salt water or spray which have been swept into the atmosphere by the wind; and that, with the exception of the salt drops thus raised, though only when the sea is ruffled by the wind, sea-air contains neither muriates nor uncombined muriatic acid. At first sight we had some doubt whether this would account for the injurious effects of sea-air on vegetation; because the presence of common salt, if not in excess, is known to be beneficial. But perhaps the salt when united with the soil may operate as a cordial to the roots, while it may be noxious when in immediate contact with the stem or leaves, as is often the case with manure injudiciously applied close to the roots of plants.

Congelation in hot climates due to radiation.

In the method of forming ice in India by exposing water during the night to the aspect of a clear sky, the effect was for some time ascribed to evaporation; but Dr Wells ascertained that the water thus exposed gained in place of losing weight. Now it could only gain by being cooled below the dew point of the incumbent air; for it is only in that state that the air could yield a portion of its moisture to the water; and therefore the cold must be the effect of radiation, and not of evaporation. This was farther evident from the circumstance that wind which ought to have increased the evaporation prevented the freezing altogether. But independently of these considerations, water exposed in the open air could never be cooled to the freezing point by evaporation alone in a hot climate. Where such a thing occurs, the air must be unusually dry, even after its temperature scarcely amounts to 40°, or the atmospheric pressure must be very small; because the utmost evaporation that can be produced artificially under the ordinary pressure will little more than cool a wet thermometer from 40° to 32°; and the cooling effect on a vessel with water is not nearly so great, especially in the open air, if care be taken to avoid the influence of radiation under the aspect of a clear sky. It is true that, at Benares for instance, the surface of the ground, after becoming very cold by radiation, sometimes renders the incumbent still air also pretty cold; but this, by bringing the air to a state of saturation with moisture, totally unfits it for aiding the freezing by evaporation.

So great is the difference of opinion respecting the influence of electricity on evaporation, that we suspect it has not yet been sufficiently investigated. The use of evaporation in the arts and manufactures will be found under the respective articles. In addition to the various works noticed in this article, see Dr Thomas Young's *Natural Philosophy;* Wells *on Dew;* Pouillet's *Elemens de Physique et de Météorologie.* A variety of articles on this subject will be found in the different volumes of the *Philosophical Transactions,* and other scientific journals. (H. M—E.)

EVE, the mother of the human race. See ADAM.

EVECTION. See ASTRONOMY, iv. 36.

EVELYN, JOHN, author of the *Sylva, Memoirs,* &c., was born in 1620 at his father's seat of Wotton in Surrey. He was educated at the free school of Southover, near Lewes, whence he removed in 1637 to Baliol College, Oxford; on leaving which he began the study of law in the Middle Temple. In 1641 he went to Flanders, where he served for a short time as a volunteer; but soon returning home, he joined the king's army in the struggle now begun with the parliament. The following year saw him once more bent on foreign travel, and he accordingly set out with an old college companion on a tour through France, Italy, and Switzerland, in which countries he spent the next seven years of his life, studying men and manners, statistics and science, polite literature and the fine arts. In 1647 he married a daughter of Sir Richard Browne, the English ambassador at the French court; and when that gentleman's estate of Sayes Court was sequestered by parliament, Evelyn was allowed to become the purchaser of it. Here he lived in strict retirement during the period of the Protectorate, engaged in laying out the grounds and gardens, and turning to profitable account the results of his continental studies. During this period also he published a translation of the first book of Lucretius; Chrysostom's *Golden Book for the education of Children;* and the *French Gardener and English Vineyard.* At the Restoration, however, he began to take an honourable though not conspicuous part in public affairs; was appointed one of the commissioners for taking care of the sick, wounded, and prisoners, during the Dutch war; commissioner for the rebuilding of St Paul's after the great fire (of which an admirable account will be found in his Journal); and a member of the Board of Trade. He was also made a member of the Council of the Royal Society, to whose Transactions he continued all his life to contribute papers on the subjects towards which his early studies had been directed. His favourite pursuits were gardening and planting, upon which he wrote a number of treatises, appended to the fifth edition of the *Sylva, or a Discourse on Forest Trees, and the Propagation of Timber in His Majesty's Dominions,* published in 1644 by order of the Royal Society. The object of this treatise was to encourage planting throughout Great Britain, and it produced the desired effect in a manner very gratifying to the author. In 1699, on the death of his elder brother without children, Evelyn succeeded to the family estate of Wotton, to which he removed from Sayes Court, where he had lived happy and respected for upwards of forty years. He was succeeded in the occupancy of that house by the Czar Peter, who with his suite made sad havoc among Evelyn's well-trimmed yew-hedges and elaborate parterres. Evelyn did not live very long to enjoy his new position as head of his family; he died February 27, 1705, in the eighty-sixth year of his age. In the humbler walks of science Evelyn was a successful and persevering inquirer; a valuable pioneer, as he himself used to say, in the service of the Royal Society. His moral character was irreproachable, though he lived at a time when vice was an almost indispensable passport to favour and promotion; and the purity of his morals, his piety, his schemes of active benevolence, and the intellectual nature of his pursuits, were all such as to earn for him the respect even of the court-profligates, to whom his example was a standing rebuke. Altogether our history affords few better specimens of the accomplished and well-principled English gentleman. The most valuable of Evelyn's works (leaving out of account the *Sylva* already mentioned), is his *Diary and Correspondence,* and the *Memoirs of his Life and Writings,* which are valuable not only on account of their literary merits, but also as throwing much light on the times in which their author lived. His other works, which have long since been for the most part superseded, embrace treatises on Sculpture, Architecture, Painting, Numismatics, and certain social questions. A very detailed list of them will be found in Watt's *Bibliotheca.*

Evemerus.

EVEMERUS or EUHEMERUS, a Sicilian mythographer, who flourished in the latter half of the fourth century B.C.

He is noted chiefly for his *Sacred History*, the materials of which, he said, were derived from inscriptions on the walls and columns of temples in various parts of Greece. In this work he introduced a new method of interpreting the popular myths, asserting that the gods who formed the chief objects of popular worship had been originally heroes and conquerors, who had thus earned a claim to the veneration of their subjects. Till the end of the last century there were many who accepted this system of Evemerus, and the early Christians in especial appealed to it as a confirmation of their belief that the ancient mythology was merely an aggregate of fables of human invention. Evemerus, who was a firm upholder of the Cyrenaic philosophy, was violently attacked by some of the ancient authors, and even accused of atheism; not so much, however, on account of his mythology, as because he declared that he had visited Panchæa, a sort of southern Thule, and there picked up much of the information which he embodied in his work.

EVESHAM, a municipal and parliamentary borough and market-town of Worcestershire, 15 miles S.E. from Worcester, and 96 miles from London. It is situated in the vale of the same name on the Avon, over which there is an ancient stone bridge of eight arches, connecting it with Bengeworth parish, which forms part of the borough. The land around the town is of great fertility, and occupied chiefly as market gardens. The borough returns two members to parliament, and is governed by a mayor, four aldermen, and twelve councillors. Pop. (1851) 4605; registered electors 349. Evesham is a place of considerable antiquity, a monastery having been founded here as early as the beginning of the eighth century. Of this building almost the only remnant is a magnificent tower, built not long before the Reformation. This tower, which is considered the best extant specimen of the pointed ecclesiastical style of the sixteenth century, is 110 feet high, and 28 feet square at the base. The town has recently been much improved; the two main streets are wide and clean. Evesham has an old town-hall, several fine churches, a grammar-and other schools, savings-bank, dispensary, and several charities. The inhabitants are chiefly employed in the rearing of garden produce. Market-day, Monday. At Evesham was fought, on 4th August 1265, the famous battle between Prince, afterwards Edward I., and Simon de Montfort, Earl of Leicester, in which the latter was totally defeated, and he and his son slain.

EVIDENCE.

By evidence, taken in the widest sense of the term, is meant whatever is the ground of assent, or tends to generate belief in the statement of any fact or truth. The means by which men acquire a knowledge of all the facts or truths which evidence brings before them may be referred to two sources; for either the perceptive faculties of the individual himself, or the observations and conclusions of others, present them to the mind. The first may be called the evidence of personal experience, the latter is generally known as the evidence of testimony. The former embraces all the phenomena of consciousness, the intuitive perception of our own existence, and of what is actually passing in our minds, and also all the phenomena of the outer world afforded by the senses. The knowledge, therefore, which is derived from the evidence of sense, of memory, of deduction, induction or inference, and analogy, may be referred to this head; and its chief characteristic is, that it is superior in degree to that obtained through the experience of other men, inasmuch as we rely solely on the operation of our own faculties, and the belief resulting therefrom is lively and strong. In some instances this kind of evidence is fitted to produce belief in the very highest degree, as in the phenomena of self-consciousness, in an act of memory or perception, in which the evidence is immediate and irresistible, and commands instant belief. No process of reasoning, either demonstrative or probable, being necessary in its acquisition, the knowledge and the evidence on which it is believed are both called *intuitive*. Again, in regard to those truths which are not intuitive, but are embraced under the subjects investigated by demonstration, analogy, and induction, the knowledge is not immediate, but attained through the medium of reasoning. In the evidence of demonstration—the process by which a result is shown to be a necessary consequence of the premises from which it is asserted to follow on the supposition that these premises are admitted—the belief reaches to the highest degree of certainty; but induction and analogy only afford that assurance which amounts to high probability: they never reach to necessity, or absolute certainty; and of such truths the most that is affirmed of them is, that there is no reasonable doubt concerning them. Hence the evidence employed to discover these truths has received the name of moral or probable evidence, which is thus distinguished from the intuitions of consciousness, or the demonstrations of necessary relations. The word *probable* is not to be taken as indicating an inferior degree of evidence, but as a species, in which the truths of fact to be proved are not *necessary* but *contingent*. According to this definition, moral evidence includes those judgments which are based on the testimony of others vouching their observation or experience.

It is manifest that by far the greater portion of our knowledge is obtained through other men, and received by us as true on the evidence of testimony. So limited indeed is the experience of each individual of the human race, that without this communicated knowledge men could never have advanced beyond a rude state of existence. But, on the other hand, this source wants that certainty of truth which personal observation and reflection afford; for the degree of assurance which is produced in the human mind necessarily varies according to our confidence in the veracity of the narrators, the opportunities they have had, and the probability of the facts themselves. It follows that the credit due to the testimony of a witness depends, 1*st*, On his trustworthiness, and, 2*d*, on the probability of the fact attested. Two elements enter into the trustworthiness of a witness; 1*st*, His means of knowledge, and, 2*d*, his desire to report the truth.

In reference to the first of these, the witness must have had sufficient opportunity of observing what he describes, and he must have intellectual capacity to observe and remember the facts, and judge of their authenticity and character. As Bentham has remarked, "Where the botanist sees a rare and perhaps a new plant, the husbandman sees a weed; where the mineralogist sees a new ore, pregnant with some new metal, the labourer sees a lump of dirt, not distinguishable from the rest, unless it be by being heavier and more troublesome."

In estimating the intention of the witness to narrate the truth, we are influenced by various considerations. If he be a person on whose evidence we have relied on former occasions, or if we have credible proof of his having been a veracious witness, or if he be a stranger, or have formerly misled us, we either receive the testimony implicitly or with caution, or reject it altogether. The honesty of a witness is further affected by the presence or absence of motives to falsify his evidence. In proportion as we have no reason to

suspect the witness to be influenced by interest or passion, our confidence in the evidence rises. Other elements affect our belief in the trustworthiness of a witness; such as the likelihood of contradiction which might ensue did he deviate from the truth, his deportment in delivering his testimony, and the support his evidence receives from the concurrence of other witnesses. The last point is of the utmost importance, and where no suspicion of collusion or connivance exists, the agreement of several witnesses places the fact testified beyond all doubt. The credibility of each individual may then be left unconsidered, for that several should concur in all essential particulars and yet be insincere or incorrect amounts—such is our faith in human testimony—to an impossibility.

The degree of belief we give to matters of fact attested by others is much affected by the probability of the fact itself, that is, by its accordance with our previous experience. When an alleged fact is so repugnant to the laws of the material world that no amount of evidence can induce us to believe it, it is said to be impossible. But impossibility is a relative term, and bears a certain ratio to the state of human knowledge. In such circumstances, men conceive that the evidence is a mistake, either intentional or unintentional, and refuse to believe it. This subject has acquired great importance in consequence of Hume's argument, that miracles, that is, supernatural events, or, as they were wrongly called by him, "violations of the laws of nature," are incapable of proof, because they are contradicted by our ordinary experience and observation. The refutations of his argument have been numerous, and no farther notice need here be taken of it than to quote an observation from one of the most recent writers on the subject. Mill, in his *Logic*, has observed, "All that Hume has made out is that no evidence can prove a miracle to any one who did not previously believe the existence of a Being with supernatural power, or who believed himself to have full proof that the character of the Being whom he recognises is inconsistent with his having seen fit to interfere on the occasion in question." Hence, to establish the impossibility of a miracle, it is required to show that the intervention of supernatural agency is incompetent, or would not be exercised in producing the effect. The "firm and unalterable experience," upon which Hume so much relied, affords too narrow a basis even for sceptical philosophers in the ordinary affairs of life, and they are content to receive much of their knowledge, not from their own experience, but from that of other men. But it is true that statements which accord with facts we already know are received upon a lower degree of evidence than those which appear to us improbable in the present state of our knowledge. If the fact be of the latter kind, or entirely beyond the sphere of experience, we require, indeed, stronger evidence, but we should beware of undue distrust. This is shown in the story so often quoted from the days of Locke, in which the king of Siam, who was told by the Dutch ambassador that in his country water sometimes became so solid that an elephant might walk over it, thus replied, "Hitherto I have believed the strange things you have told me, because I look upon you as a man of sobriety and truth, but now I am sure you lie." The test of probability then is not personal experience only, but the nature and quality of the evidence adduced are also elements to be considered; and in proportion as the witnesses are more numerous and of higher credit, and have no interest to speak contrary to the truth, and are uncontradicted by others, the matter of fact ought to be more or less believed.

Besides these there are other principles on which reliance on testimony is based, and among others there may be mentioned the consistency of the different parts of the narrative. There must be no contradiction between the various facts attested by the witness. For if it be self-contradictory, the evidence cannot be received. But if the contradiction lies in some cause or effect erroneously added by the witness to the fact, then the latter remains unshaken; for it is only the inconsistency of the facts themselves which destroys the credibility of a witness. If, again, there be several witnesses to the facts, the weight of their testimony depends on their mutual consistency. If one witness should either omit a matter of importance attested by another, or contradict the other's narrative by some positive discrepancy, discredit is thrown on the evidence, which will fall to be rejected altogether, or a preference given to one rather than another according to the trustworthiness of the particular witnesses.

In all questions of fact there appears to be in the human mind an instinctive reliance on testimony based on the knowledge of the natural inclination of men to speak the truth. These principles are relative and correlative of each other, and have been called by some the instinctive principle of credulity and counter principle of veracity. It is not necessary here to inquire whether belief in testimony is an ultimate or innate principle of the human mind; it is undoubtedly true that it is modified by experience. But there is another basis, upon which circumstantial evidence rests, of a totally different character. It is founded wholly on the relation and connection subsisting between collateral facts or circumstances and the fact to be proved. It is similar to the principle so well known in physical and moral investigations and analyses—the impossibility of accounting for the facts on any other hypothesis. It is thus the philosopher or historian endeavours to establish some doubtful truth by inference or analogy more or less remote, and a chain of facts and circumstances connects the accused with the crime in such a way as to exclude the hypothesis of innocence. It is in questions of this nature that the judgments of men are found continually to differ. The most opposite opinions are formed as to the credence and weight due to the circumstances adduced; and a scientific question, or historical fact, or alleged crime, which one man considers as not only probable but as certain truth, another holds to be impossible. The hypothesis is more likely to be true in proportion to the greater number of circumstances; and in general the mind is satisfied if the evidence on the whole coincides with and supports the hypothesis which it is adduced to prove, and a conclusion as satisfactory as direct evidence can produce is frequently founded on circumstances alone. But in criminal cases, in which circumstantial evidence is so frequently used, greater strictness is required. It is essential that every circumstance necessary to the hypothesis should be satisfactorily proved. If one of the links be wanting, or not established by proof, then the basis is defective, and no conclusion can be drawn. Moreover it ought to be impossible to draw any other conclusion from the circumstances than that proposed to be proved, for their possible combinations are so numerous that the acutest intellect may be baffled in discovering the connecting link. But when every other hypothesis is excluded, the conclusion is forced upon the mind with an even stronger conviction than in direct evidence, for in the latter case the testimony of personal observation is felt to be more fallible than the connection between the circumstances and the conclusion drawn.

Various arbitrary divisions of evidence have been made of which it is here necessary to mention only two. Evidence is either direct or indirect—original or transmitted It is direct, when the fact is attested by those who speak from their personal knowledge immediately; it is indirect, when the fact is inferred from other collateral facts clearly proved, which are supposed to have a relation proximate or remote to the fact in controversy. The latter is the circumstantial evidence of jurisprudence. Evidence is original, when it rests solely on the credit of the witness who attests

the fact; it is transmitted when it rests also on the veracity and competency of some other person, who has transmitted it to the reporter. It is manifest that if a man testify facts not lying within his own knowledge, but from information derived from others, the security for their truth is weakened in proportion to their remoteness from the original observer. "A credible man, vouching his knowledge of the thing itself," says Locke, "is a good proof; but if another equally credible do witness it from his report, the testimony is weaker, and a third that attests the hearsay of an hearsay is yet less considerable." Yet many historical truths depend on no other evidence than hearsay; and it is apparent that in the ordinary business of life, and in historical and philosophical investigation, transmitted evidence is frequently of the greatest value, being often the sole guide on which the inquirer proceeds.

Evidence (*Judicial*).—In the preceding part of this article, the rules of moral or probable evidence have been given. In jurisprudence, the practical importance of the subject has attracted much attention, and in every country a body of artificial rules has been framed on certain exclusive principles, differing considerably from those of natural or moral evidence. The divergence from natural equity has been so complete, that Mr Bentham states it to be his belief that if all the grounds of exclusion were collected into one from the various systems, including the Gentoo and Chinese, no witness in any cause could possibly be examined at all. In England the law of evidence in early times was extremely loose, and what was admissible seems to have depended on the tendencies of the judge. Accordingly, in the early state trials hearsay evidence is not unfrequently admitted; but though the law of evidence is a modern creation, the leading principles on which it is founded have been known from the earliest times; and the contrast between the two epochs seems to lie in this, that the judge now administers the law on fixed exclusive principles. The necessity or value of resorting to such exclusive principles has been denied by Bentham. Here it may be shortly observed that jurists trace the origin of the distinction between legal and natural evidence to the necessity of preventing fraud in the speedy action of judicial tribunals—of limiting the discretionary power of the judge as to the nature of the evidence to be admitted—of providing more certain tests of truth than are necessary in the ordinary affairs of life, and in the characteristic differences between legal and historical investigations. The result of these considerations has been to annex an artificial weight to particular evidence, or to set up certain exclusive rules.

The first general principle or rule is, that the best evidence of which the case in its nature is susceptible ought to be adduced. "The true meaning," says Gilbert, "of the rule of law that requires the greatest evidence that the nature of the thing is capable of, is this—That no such evidence shall be brought, which, *ex natura rei*, supposes still a greater evidence behind in the parties' own possession and power." This rule leads to the exclusion of all secondary evidence so long as any primary exists. Thus a written contract must be proved by the production of the deed itself, if it is within the power of the party. No copy or parole can be substituted in room of the principal unless it be proved to be destroyed or lost. Another consequence of this rule is, that all *hearsay* is rejected. Hearsay or transmitted evidence in law includes not only verbal reports, but also writings transcribed from the originals. It is excluded, not only because it supposes that better evidence exists, but it is also intrinsically weak, and affords a cover for the practice of fraud. Yet, where the necessity of the case requires it, hearsay ought to be admitted. Accordingly, it is received, 1*st*, in matters of public and general interest, where ancient rights are concerned, and the persons are supposed to be dead; 2*d*, in the case of declarations and entries made by deceased persons against their interest; 3*d*, both in criminal and civil cases the dying declaration of the injured party and the statements of a competent deceased witness are allowed to be proved under certain conditions.

The next general rule of evidence is, that the burden of proof lies on the party maintaining the affirmative of the question at issue, conformably to the maxim of the Roman law, "Ei incumbit probatio qui dicit, non qui negat." In explicating this rule, the onus of proof is determined by the affirmative in substance, not the affirmative in form; and the burden may be shifted by presumptions, either of law or of fact, or the capacity of the contending parties to adduce the evidence.

Two other general rules of evidence may be shortly stated without comment. The evidence must correspond with the allegations made by the parties. All beyond this is irrelevant, and the proof, if offered, is to be rejected. This rule confines the evidence to what is material and necessary to prove the case of the litigant. The other rule is, that the evidence must be sufficient to prove the substance of the issue. This rule protects the litigant from excessive strictness on the one hand, and on the other requires that nothing essentially descriptive of the claim or charge shall be wanting.

So many rules of exclusion have been recently abolished by statute, that it may be well to enumerate some of the objections of former and later times to the admissibility of witnesses.

1*st*, By the ancient practice of most European countries women were inadmissible; and even when admitted, their evidence was not considered equivalent to that of a man. So late as 1824, in some of the Swiss cantons, the testimony of two women was equal only to that of one man. In Scotland there exists a remnant of the former practice in the exclusion of females as witnesses to the subscription of deeds.

2*d*, Infamy of character was formerly a ground of exclusion. Wherever one had been convicted of a crime inferring infamy, he was perpetually disqualified. This was at first modified, and at length altogether abolished by Lord Denman's Evidence Act (6th and 7th Vict., cap. 85): in Scotland the equivalent statute is the 15th Vict., cap. 27.

3*d*, No witness can now decline to give evidence on the ground of relationship; and, with the single exception of husband and wife, relations may now be compelled to give evidence both for and against each other. By a statute passed in 1853, which, however, applies only to England, husbands and wives are competent and compellable to give evidence either for or against each other in any suit, with the exception of criminal cases. In both countries, where the party injured is one of the spouses, the other is of necessity a competent witness in the case.

4*th*, The objection of incompetency from *interest* has been also recently abolished. So far back as the time of Fielding, the impolicy of this ground of exclusion was observed; in his *Amelia* he thus criticises the law of evidence on this head:—"There is no branch of the law more bulky, more full of confusion and contradiction, I had almost said absurdity, than the law of evidence as it now stands. One rule of this law is that no man interested shall be sworn as a witness. By this is meant pecuniary interest; but are mankind governed by no passion but avarice? Are not pride, hatred, and the other passions, as powerful tyrants in the mind of man? And is not the interest which these passions propose to themselves, by the enjoyment of their object, as powerful a motive to evil as the hope of any pecuniary interest whatever?" Notwithstanding objections so apparent, the exclusion arising from interest was firmly fixed in our law, and was only recently removed in regard to witnesses, and still more recently in regard to the parties to the suit themselves.

5th, The only other grounds of objection, to which reference need be made, which have been removed by the legislature, are enmity, agency and partial counsel. It appears to be doubtful whether the last two ever did more in England than affect the credibility of the witness, and in Scotland they are now in the same position. The cause of this enlightened course of legislation is well stated in the preamble of Lord Denman's act, which recites that the inquiry after truth in courts of justice is often obstructed by incapacities created by the present law, and it was desirable that full information as to the facts in issue, both in criminal and civil cases, should be laid before the persons who are appointed to decide upon them, and that such persons should exercise their judgment on the credit of the witnesses adduced and on the truth of their testimony. The above objections have now accordingly become simply questions of credibility in the hands of the jury, and have been wholly removed from the province of the judge. The tendency of legislation and the inclination of our judges at the present time is to admit all evidence where it is *original;* when such testimony is excluded, all attainable proof bearing on the question in dispute may be destroyed, and substantial injustice done to one or other of the contending parties.

The means by which the matter of fact in dispute is proved before a judicial tribunal are called the instruments of evidence, and are either written or unwritten.

1st, Of Unwritten or Oral Evidence.—The law compels every one who is in possession of evidence bearing on the matter in dispute, to be a witness, and to attend as such at the trial. The witness must answer all relevant questions which do not criminate himself. And the court will interfere to protect a witness who is pressed to answer questions tending to bring disgrace upon him, unless the ends of justice clearly require it. All persons, male or female, who are of sane mind, and capable of understanding the oath to speak the truth, are admissible as witnesses.

Before the recent legislation, to which reference has been made, many rules existed as to the admissibility of witnesses. The only grounds of incompetency still existing in our law are two in number:—*1st*, From want of reason and maturity of intellect; and, *2d*, From professed want of religion.

Under those incompetent from want of reason, are included all idiots from birth, and fatuous persons, who have wholly lost intellect and memory, and those who have reduced themselves to that condition by their own vicious acts, as drunkards, and lunatics during the period of derangement; but lunatics in their lucid intervals, and monomaniacs in matters apart from the particular delusion, appear to be competent witnesses.

Children of tender years are likewise excluded from want of maturity of intellect. The old lawyers stated broadly that "infants under fourteen years of age are not to be examined upon their oath as witnesses." In modern times the rule is relaxed, and children are sworn as witnesses between the ages of twelve and fourteen, where the judge is satisfied that they understand the nature of an oath. In reference to children below twelve years, their admissibility depends upon the sense and reason, and the general intelligence they manifest, and their understanding as to the impropriety of falsehood; but they do not give evidence on oath, but simply emit a declaration, and the weight of the testimony is a question exclusively for the jury.

The only other ground of incompetency now known arises from the want of religious belief. Where the witness does not believe in the existence of a God, in the obligation of an oath, and in a future state of rewards and punishments, he is not admissible. It is not sufficient that he believes himself bound to speak the truth, merely from a regard to character, or the interests of society, or the fear of punishment by the temporal law.

2d, Of Written Evidence.—Documents, which may be put in evidence, are either public or private. To the former head may be referred acts of parliament, the judgments of courts, the acts of public functionaries, entries in public registers, and extracts from judicial records. The mere inspection by the court of evidence of this kind is sufficient. Acts of parliament are either public or private; those which are public are presumed to be known to all, and a reference by citation of the statute book is sufficient; as to those which are private, a copy compared with the official roll must be produced. Extracts of judicial proceedings under the seal of the court, and the proceedings of foreign judicatures, are received when authenticated in the manner required by the laws of the country. So entries in various public registers, as the register of births, deaths, and marriages, or of probative deeds, when certified by the proper official officer, are probative. Among *private* writings are regular deeds, wills, notarial instruments, and the executions of officers of the law. These must be executed and authenticated in the manner prescribed by the law of the country where the contract or obligation is entered into; and the execution of the deed must be proved by one at least of the attesting witnesses; but in Scotland, when certain solemnities required by statute are observed, a presumptive evidence arises in favour of the instrument, which is probative in all respects until it is challenged or reduced on the grounds of forgery, fraud, or error. Documents thus authenticated and proved are the highest species of evidence, and are superior to any oral proof of the transaction that could be offered. In truth, it is in general incompetent to endeavour to supersede or contradict a written instrument, or supply a defect or explain the intention of the writer by parole evidence. Parole is, however, competent in the challenge of a deed where fraud is alleged, or to prove a mistake or error.

The statutes passed recently to alter and amend the law of evidence have simplified and improved it to a great extent. Nor can there be any doubt that the course of legislation has been enlightened and in the true direction; nay, so much has been done, at least in removing grounds of *exclusion*, that little remains to be effected. Yet the expediency of rejecting any witness for incompetency may well be doubted. Wherever one has been an eye-witness to the facts in dispute, or can give testimony bearing on these, the law ought to admit the evidence. It is doubtful, therefore, whether the want of religious belief should remain a recognised ground of incompetency. Respect for character and social position, the principles of natural morality, and the fear of punishment in this life, may in such cases be as strong checks on perjury as the more formal appeal to divine vengeance in taking an oath. Unsworn testimony is received in certain instances; it might be extended to those who deny the obligation of an oath, but admit the strength of moral law, and the duty to society that each man should speak truth. Again, the English system of evidence neglects the preservation of written testimony. Public documents, deeds, and instruments used in the transmission of real property, contracts, and wills, ought to have been an object of solicitude to the government; and a speedy and cheap means of preserving such evidence has still to be discovered and put in practice. Bentham, and others after him, argue for the admission of hearsay or transmitted evidence under certain forms and conditions, so that a jury may weigh its value, and admit or reject it as circumstances demand. But the opening which this would give to fraud and dishonesty seems too palpable to hazard the experiment. In admitting it, all personal responsibility, and the safeguards of cross-examination, of publicity, and of the solemn obligation of an oath, would be removed. All those qualities in a witness on which his credibility depends, his disposition to speak the truth, and his power of observing and remembering, would also be unknown. Besides, it is often impossible to trace the source through which

hearsay is derived, or by how many channels it has been transmitted, till it reaches the party who is willing to give it forth as evidence. Its very existence, moreover, supposes that there are witnesses who can speak to the fact from their personal knowledge, and who ought therefore to be produced. Its infirmity is indeed self-evident, and when offered in a court of justice, in proof of recent events, it is wisely rejected.

The subject of evidence is admirably treated at great length, in an American work by Greenleaf, which has reached a sixth edition. The most recent English treatises of authority are those of Mr Starkie and Mr Best. (A. M.)

EVIL can only be defined as the antithesis or negation of *good*. In the abstract, evil is want of conformity to the standard of good, whatever that may be; in the concrete, evil is anything that comes short of what is perfectly good. Evil is thus a simply negative conception, *i. e.* relatively to good, which has a positive existence *per se*, merely predicates non-existence in certain cases. Origen (*de Princip.*, ii. 9, 2): "Πᾶσα ἡ κακία οὐδέν ἐστιν, ἐπεὶ καὶ οὐκ ὂν τυγχάνει." Augustine (*de Civ. Dei*, l. ii., c. 22): "Cum omnino natura nulla sit malum, nomenque hoc non sit nisi privationis boni," &c.

A threefold division of evil has been signalized, viz., into *Metaphysical*, *Physical*, and *Moral*. Leibnitz has discriminated these thus: "Metaphysicum generatim consistit in rerum etiam non intelligentium imperfectione; physicum accipitur speciatim de substantiarum intelligentium incommodis; morale de earum actionibus viciosis" (*Causa Dei Assert.*, § 30–32). Or we may state the distinction thus:—Every existence has an ideal perfection; when it comes short of that, there is evil. Every intelligent existence has its own happiness as its end; when it is impeded in the pursuit of that end, there is evil. Every intelligent existence is subject to certain moral laws, in obedience to which it is bound to seek that end; whenever any of these laws is evaded or transgressed, there is evil. It may, however, be doubted whether the first of these should not, as well as the other two, be restricted to *intelligent* existences; inasmuch as it is only as it affects them, that imperfection in themselves or in other existences is an evil. It may be further observed, that even in reference to intelligent existences imperfection is not so much an evil as a possible cause of evil; for limitation, or even defect, if it do not lead to unhappiness or sin, cannot with strict propriety be called an evil. It may be as good for a creature to be imperfect *quoad* an ideal standard of perfection, as to be perfect—provided no consequences injurious to his physical or moral well-being result thence.

We may satisfy ourselves, then, with a twofold division of evil—physical and moral; understanding by the former whatever is opposed to good in the sense of happiness, by the latter whatever is opposed to good in the sense of rectitude or virtue. The terms *physical* and *moral* seem sufficiently definite for ordinary purposes as thus used; but if a more exact and scientific expression be required, we may take that of Kant, who discriminates evil into the absolutely evil and the relatively evil; the former designating that which is opposed to the absolutely good, and which cannot be chosen by perfect wisdom and holiness, either for itself or as a means to an end; the latter denoting that which is opposed to the relatively good—the good for a special end, and which may be chosen by perfect wisdom and holiness, if not for itself, yet as a means to an end.

Moral evil has often been identified with *sin*. It would be more correct to say that sin is moral evil viewed under a certain relation, viz., as difformity from an express law: "illegalitas seu difformitas a lege," Calovius *System. Locc. Theoll.*, v., p. 14. Moral evil is the absolutely evil, the *malum in se;* sin is moral evil as a thing forbidden by God, *malum prohibitum;* and as the commission of what is forbidden entails guilt and exposes to blame, this latter becomes also *malum culpæ*.

The relations of physical and moral evil may be stated thus:—1. Physical evil is by the divine ordinance the consequence of moral evil, and frequently the outward exponent of what is in itself hid from created vision; 2. Physical evil is *malum pœnæ*, the punishment which is made to fall upon the being who has been guilty of the *malum culpæ:* Grotius (*De Jure*, l. ii., c. 20, § 1)—"Est autem pœna generali significatu malum passionis quod infligitur ob malum actionis;" Augustine (*cont. Adim.* c. 26): "Dupliciter appellatur malum, unum quod homo facit, alterum quod patitur; quod facit peccatum est, quod patitur pœna. Divina Providentia cuncta moderante et gubernante, ita homo male facit quod vult, ut male patiatur quod non vult;" 3. Physical evil may often be the means of preventing moral evil by securing the opposite good; it may thus become not merely, as Hierocles terms it, πονηρίας ἰατρική, but even a subsidiary or mediate good: Leibnitz (*De causa Dei*, § 35)—"Mala physica interdum fiunt bona subsidiata tanquam media ad majora bona;" 4. The converse may not lawfully take place; moral evil may not be resorted to as a means of averting physical evil; in the government of the world God never directly wills evil that good may come, and he has forbidden this to us; 5. It is nevertheless possible, for aught we know to the contrary, that moral evil may be the condition without which intelligent creature existence cannot reach its highest and most perfect development, *i. e.*, become entirely and for ever superior to all defect and evil; and for this reason, though not directly willed by God, it may be permitted by him.

Attempts have been made to subvert this distinction between physical and moral evil, and to generalize all evil under one category. On the one hand, the sensualistic or eudaimonistic school, by resolving all good into happiness, make pain and suffering the only kind of evil that can befal a creature; and, on the other hand, it has been contended that sin is the only evil, as without it there would be no suffering and no punishment. But both these generalizations are fallacious. In the former, sin is confounded with its concomitant penalty; in the latter, the concomitant penalty is subsumed as a part of the sin of which it is the effect or result. As the pleasure which God has made to attend on goodness is not itself goodness; so the pain which he has made to attend on sin must ever be carefully discriminated from sin itself.

Of all questions connected with evil the most perplexing is that which respects its *origin*. Πόθεν τὸ κακὸν; this is an inquiry which, from the dawn of speculation, has excited the curiosity and exercised the ingenuity of thoughtful men. Our limits permit us only to state in the briefest manner the different hypotheses which have been suggested for the solution of this problem. These may be classed under three heads—the Dualistic, the Pantheistic, and the Monoistic. Of these the Dualistic may be regarded as the most ancient and most widely diffused, as well as perhaps the one most likely to occur to the mind on first contemplating the phenomena of the world. According to it, good and evil are absolutely distinct essences, the products of two original principles, one of good and the other of evil, from whose agency the good and evil we see actually mixed in the world have respectively flowed. This hypothesis has appeared in different forms, of which the principal are these: 1. *Parseeism*, which supposes that the universe was created by two rival powers, Hormuzd or Light, and Ahriman or Darkness; the latter of whom produced some evil thing for every

good thing which was made by the former. 2. *Hylism*, which regards matter (ὕλη) as the original eternal principle of evil, in opposition to the good spirit or God; whether this original Hyle be viewed as feminine and passive, as in the Chinese cosmogony, or as a dead and formless mass quickened by a blind senseless soul, as among the Greeks. 3. *Gnosticism*, which is the heathenish doctrine modified by certain Christian opinions, and exists under two principal aspects as presented by (1) the Syrian Gnosticism, Marcionism, and Manichæism, all of which closely approximate to the Parsee doctrine, and (2) the Alexandrian Gnosticism, as developed by Basilides and Valentinus, and in which the Hellenic doctrine of the Hyle predominates.[1]

In the Pantheistic hypothesis, evil and good are viewed as only varied manifestations of the one original principle. This appears in its grossest form in the Hindu system, and in that of Spinoza; but it is also to be traced in some of the more refined speculations of the modern absolute philosophy of Germany, as *e. g.* in the earlier philosophy of Schelling, who placed evil in the discord, and good in the concord, of the individual will with the universal will, but held both to be one in God.

In the Monoistic hypothesis, evil is regarded as either the necessary condition of good, or as a result flowing from the necessarily limited and imperfect nature of creature existence. This latter view, which, from the prominent use by its advocates of the expression "mundus optimus," is generally known as the *optimist* view, is that adopted by Augustine, by Leibnitz, and by Archbishop King, all of whom have attempted to reconcile the existence of evil within the government of a perfectly holy, good, and powerful being, by treating it as a necessary result of creature limitation; though there be differences on subordinate points between them.

It must be admitted that none of these modes of solving the difficulty is satisfactory. The Dualistic hypothesis has found no supporters of any note in more recent times, if we except Bayle; whose defence of it, however, is to be looked upon rather as a piece of literary gymnastic than as the result of serious conviction. The Pantheistic hypothesis contradicts our moral consciousness, and is besides based on a theory of the relation of the universe to God which reason refuses to authenticate, and which piety abhors. The doctrine that evil has its origin in the necessary imperfection of the creature has, under one or other of its modifications, found the largest number of supporters in modern times; but when stripped of the garnishing in which its advocates have enveloped it, this hypothesis will be found to involve a fallacy so gross and palpable that it seems surprising that it should have ever imposed upon any logical understanding. For in what sense are we to take the weighty word *imperfection* as here used? Take it in a moral sense as equivalent to *faultiness* or *vitiosity*, and the proposition that there is evil in creation because creation is imperfect, becomes a purely identical one, and the origin of evil is virtually referred to the Creator, of whom in this case we must say with the Epicureans "aut vult, aut non potest tollere malum." Take it in a metaphysical sense, as equivalent to *limitation*, and the assertion simply affirms the creation to be potentially evil; it in no way explains how that potentiality was developed into an actuality, which is the real question at issue.

On this question the Bible throws no light; it merely informs us that evil did not originate with man or in this world, but was brought hither by a spirit who had previously fallen in some other part of the universe. The Bible, however, fully authorizes the only conclusions to which reason can safely come on this dark subject, viz., 1. That God is not the author of evil in any sense; 2. That though able to prevent it, he has permitted it to exist; 3. That the evil permitted in the universe is not only less than the good directly willed by God, but is characterized as something intrusive and transitory, while the good is fundamental and permanent; 4. That God in permitting evil has not left it uncontrolled, but ever holds it in his power, and makes it subservient to his purposes; 5. That he will ultimately overrule this evil which he has permitted, so as to evolve a larger amount of good for his universe than if evil had not been permitted; and, *in fine*, that all that is perplexing to us in the existence of evil arises out of the limitation of our understanding, and that as in the natural world many phenomena which to the untutored mind appear anomalous, are by the philosopher seen to be in accordance with law, and necessary parts of the cosmical system, so the phenomenon of evil, which to us is so full of difficulty, may by higher intelligences—must by the highest, be seen to be in perfect accordance with the noblest order and the purest rectitude. (Bayle's Dictionary, arts. Manichæan and Paulician; Leibnitz, Essai de Theodicée, and his Causa Dei Asserta per Justitiam ejus, &c.; King on the Origin of Evil, translated by Law; Whateley's Remarks on King, appended to his edition of King's Discourse on Predestination; Lord Brougham's Dissertation on the Origin of Evil, appended to his edition of Paley's Natural Theology; Stewart's Active and Moral Powers, vol. ii., p. 109, foll.; Müller on Sin, translated by Pulsford, 2 vols. Herbart, Gespräche ueb. das Böse, 1817.) (W. L. A.)

EVIL-EYE, a malignant influence superstitiously ascribed to certain persons, in virtue of which they are supposed to injure those on whom they cast an envious or hostile look. This ancient superstition is still prevalent among many nations, especially the American Indians, and among the ignorant even in some of the most civilized countries of Europe.

King's Evil, a name formerly given in England to the disease called scrofula, from the belief that the touch of the king could effect a cure. This superstition is as old as the time of Edward the Confessor; and must have been credited even so late as the beginning of the last century, since we are told that the celebrated Dr Johnson was "touched" for the cure of this disease.

EVOCATI, in the ancient Roman army, were those soldiers who, after having received their *missio*, or full discharge from service, were called upon to do military duty as volunteers. In every great army the number of these veterans appears to have been considerable.

EVOLUTION, the act of unfolding or unrolling. In physiology it is used to denote that theory of generation which maintains that the embryon or germ pre-exists in the parent, and that its parts are merely unfolded and developed by the procreative acts. This theory stands opposed to that of *Epigenesis*, in which the germ is held to be *formed* by virtue of the procreative powers of the parent. See PHYSIOLOGY.

EVORA or EBORA, the ancient *Liberalitas Juliæ*, a city of Portugal, capital of the province of Alemtejo, is situated on an eminence in the centre of a fertile plain, 85 miles E. by S. of Lisbon. It is surrounded by ramparts flanked with towers, and has two forts, but these are all in a ruinous condition, and quite useless as means of defence. The streets are narrow, crooked, and filthy, and the houses old and ill-built. The cathedral is a magnificent Gothic edifice with an altar in the Italian style, extremely rich, and decorated with variously coloured marbles. Evora is the see of an archbishop, and besides the cathedral has several churches, convents, and hospitals, a house of charity, barracks, diocesan school, and museum. This city was in existence in the time of the Romans, and was for a lengthened period the headquarters of Quintus Sertorius, by whom it was fortified and adorned with several fine public buildings.

[1] See Neander, *Church History*, vol. ii., p. 51, Eng. tr.

An ancient aqueduct in good preservation, and the ruins of a temple, of which some columns are still standing, evidently belong to the best period of Roman architecture. Pop. about 12,000.

EVREMOND, Charles Margotelle de St Denys, Sieur de St Evremond, a literary and social celebrity of the seventeenth century, was born at St Denis du Guast, near Coutances in Normandy, April 1, 1613. Destined for the priesthood, St Evermond began his studies under the Jesuits of Paris, but at an early age, exchanging that career for the more congenial one of a military life, he obtained a lieutenancy in the guards from the great Condé, who took much pleasure in his society, and delighted in the brilliant and caustic wit by which even thus early the young soldier had forced himself into notice. Under this illustrious commander St Evremond fought with distinction at the bloody battles of Rocroi, Fribourg, and Nordlingen, in the last of which he was wounded. His irrepressible fondness for raillery and satire proved on more than one occasion the bane of his life; and Condé hearing that his young lieutenant had been laughing at his expense, deprived him of his commission. During the troubles of the Fronde, St Evremond offered his sword and his pen to Cardinal Mazarin, who rewarded his zeal with a pension and the rank of maréchal-de-camp. But his luck with the cardinal was no better than it had been with Condé. He accompanied him on his mission to negotiate the treaty of the Pyrenees, and wrote to Marshal Créqui an account of the proceedings, in which the various diplomatists and their measures were so bitterly satirized, that when the affair reached the king's ears he resolved to commit St Evremond to the Bastile. The satirist, however, being warned of the king's intention, fled to Holland, and in the following year (1662) to the English court, where he was well received, and had many powerful friends. In these two countries he spent the remainder of his long life, and could never be persuaded to avail himself of the pardon which his friends in France, with great difficulty, extorted for him from the Grand Monarque. His life at the English court was one of unclouded sunshine. He enjoyed the society of all the political, social, and literary notabilities of the day, and had from the king a pension that more than sufficed for his wants; and though on the accession of James II. he was deprived of his pension, yet at the revolution which placed William of Orange on the throne, his position was so much bettered that he obstinately refused to return to his native country. The remainder of his long life he spent in the moderate enjoyment of everything that could minister to his social and intellectual necessities. Though he was little better than a pleasure-hunter all his life, he retained his health and mental faculties unimpaired till his death, which happened September 20th 1703, in the ninety-first year of his age. The writings, both prose and poetical, of St Evremond, are, for the most part, quite unworthy of the reputation he enjoyed during his lifetime. Though the criticism of Mr Hallam may seem somewhat severe, it is in the main quite justifiable. "Nothing," says that critic, "can be more trifling than the general character of St Evremond's writings; but sometimes he rises to literary criticism, or even civil history: and on such topics he is clear, unaffected, cold, without imagination or sensibility; a type of the frigid being whom an aristocratic and highly polished society is apt to produce. The chief merit of St Evremond is in his style and manner. He has less wit than Voiture, who contributed to form him, or than Voltaire, whom he contributed to form; but he shows neither the effort of the former, nor the restlessness of the latter." Of his poetry nothing repays perusal, if we except, perhaps, the quatrain which he wrote under the picture of the celebrated Ninon de l'Enclos. Of his numerous prose works the best is his *Réflexions sur les divers génies du Peuple Romain*, which contains many acute and ingenious ideas. His letters are admirable specimens of a kind of composition in which the French have always excelled. Though by no means a religious man, St Evremond neither himself sneered at Revelation, nor encouraged others to do so; the charge of atheism preferred against him arose from the fact, that after his death certain atheistical works were published under his name, with which he had in reality nothing whatever to do. There have been numerous editions of his works, but the best is that of *Des Maizeaux*, 3 vols. 4to, London, 1705, with a life, the conjoint production of the author and his editor.

EVREUX (the ancient *Mediolanum*, and afterwards *Eburovices*), a town of France, capital of the department of Eure on the Iton, an affluent of the Eure, 54 miles W.N.W. of Paris. Pop. (1851) 11,644. The town is generally well-built, and still contains many antique timber-framed houses. The cathedral is one of the most ancient and curious in France. It is a very imposing cruciform structure, though not uniform in style. The north transept and the portal are in the flamboyant Gothic, elaborately ornamented; the west front is in the Italian style. The beautiful rose window in the south transept, and the wooden screens of the side chapels round the choir, showing the flamboyant Gothic style modified by the reviving Italian, also merit notice. The Lady chapel is of elegant architecture, with painted glass equally remarkable for its fine execution and perfect preservation. At the intersection of the nave and transepts rises an octagonal tower supported on four pillars, and surmounted by a pyramidal spire of open stonework. The church of St Taurin also displays various styles of architecture, and contains the shrine of St Taurin, a work of the thirteenth century. Among the other objects of interest are the clock-tower built in the fifteenth century, the bishop's palace, town-hall, prefect's residence, prison, theatre, public library, botanic garden, and the promenades. The chief manufactures are woollen and cotton stuffs, leather, tickings, &c. Excavations made at Vieil Evreux have led to the discovery of a theatre, baths, &c., and of various relics now deposited in the Musée d'Antiquités.

Mediolanum was the capital of the Aulerci Eburovices, and hence it took the name of Eburovices, which in the middle ages was corrupted into Ebroicæ and Ebroas; whence the modern name. In 892 it was taken and sacked by Rollo the Norman; and in 989 Richard I. duke of Normandy erected it into a county in favour of his natural son Robert, who died in 1037. He was succeeded by his eldest son Richard, who followed William the Conqueror into England in 1066, and died the following year. His son William, who succeeded him, received a large grant of lands from the Conqueror for services rendered by his father and himself. This line became extinct in 1118, when the duke of Montfort, as the nearest heir, took possession of the estates; but his claim was disputed by Henry I. of England, who took and burnt Evreux, and obliged the duke to sue for peace. In 1193, Philip-Augustus, king of France, took the town, and gave it to prince John of England (called Lackland); who, in order to conciliate his brother Richard (who was now released from captivity), invited the French garrison to a splendid banquet, and butchered his unsuspecting victims, to the number of 300, in cold blood. In revenge for this act of treachery, Philip reduced the town to ashes. In 1199 it was burnt a second time by Philip, who soon afterwards obtained permanent possession of it. In the wars between France and England, this town frequently changed its masters. In 1441, after a vigorous resistance, it fell into the hands of the French; and shortly before the battle of Ivry it was besieged and taken by the celebrated Biron.

EWALD, Johannes, the most remarkable poet of Denmark during the eighteenth century, was born November 18, 1743, at Copenhagen, where his father was a preacher

and director of the Orphan Hospital. The elder Ewald was a man of considerable ability and learning, but was prevented by ill-health from personally educating his three sons, the second and most gifted of whom, the future poet, was sent to Sleswig. Here his master allowed him to gratify his own taste in the choice of books selected for perusal. The legends of the saints which he devoured inflamed his imagination, and tempted him to the study of the Ethiopic tongues, with a view to becoming the apostle of the African negroes. By his parents he was destined for the church; but the perusal of *Tom Jones* and *Robinson Crusoe* took such a strong hold of his mind, that at the age of thirteen he ran away from school, intending to find his way to Holland, and thence take ship for Batavia, where he hoped to find a desert island like that which had originally fixed his fancy. He was overtaken in his flight, however, and compelled for the present to abandon his project. Renouncing the ecclesiastical career, as affording no adequate field for his spirit of romantic enterprise, he longed to become a soldier; and the Seven Years' war raging at this time, he enlisted as a private in a Prussian regiment of hussars stationed at Hamburg. Being transferred against his will to an infantry regiment, he deserted to the Austrian service, and there distinguishing himself was offered promotion, which however, as necessitating him to abjure his Protestant faith, he declined. To the selection of a military career he was driven not only by inclination, but by a disappointment in love, which produced a powerful impression, and exercised a lasting influence on his mind. The object of his love, whom he has celebrated under the name of Arense, bestowed her hand upon another; and this disappointment, though it cast a deep gloom for a time over the life of Ewald, was probably useful as developing in him those powers of earnest feeling and genuine pathos which distinguish many of his compositions, especially his *Death of Balder*. After he had served for a while with the Austrians in Bohemia, and taken part in the defence of Dresden against the Prussians, his family purchased his discharge, and he returned to Copenhagen. His state of mind was not such as to permit him to renew his theological studies, and he accordingly sought relief for his wounded feelings in the pursuits of literature. He was at this time only twenty-two years of age, and does not appear to have had any idea himself of the genius latent within him. An occasion, however, soon occurred which developed it. Frederick V. of Denmark happened to die at the moment when young Ewald was sunk in the deepest gloom and despondency from his repeated disappointments. In commemoration of this event he composed a funeral dirge, which attracted general admiration, and tempted the author to devote his whole energies for the future to the career of literature. Encouraged by the Royal Academy of Copenhagen, and assisted by the advice of Klopstock, then residing there, he produced his *Lykken's Temple* (Temple of Fame), and shortly after his drama of *Adam and Eve*, both works which bear the imprint of true poetic genius, but are in many respects faulty and crude. Conscious now of his weakness as well as of his power, he began a careful study of the best poetical models, especially of Shakspeare, hitherto accessible to him only in Wieland's translation. As the first-fruits of these studies, he produced in 1770 his *Rolf Krage*, a tragedy taken from the ancient history of his country, and bearing strong traces of the author's recent perusal of Ossian, of whose poems he was a devoted admirer. Though this work was greatly admired, it did little towards ameliorating his condition in life, which was rendered doubly distressing by poverty and disease. He bore bravely up against his sufferings, however, and besides the many *pièces de circonstance* by which he sought to earn a livelihood, he was able in the course of a short time to publish his *Harlequin Patriot*, a sort of satire upon the would-be reformers of his time, replete with strong common sense, pungent sarcasm, and pleasant humour. In 1773 appeared his greatest work, *The Death of Balder* (Balders Död), the subject of which is taken from the mythology of the Edda. Nothing in the same vein had hitherto appeared in the Danish tongue that could stand comparison with the wonderful poetic beauty of this drama; yet its merits were so ill appreciated by his countrymen, that they allowed him to struggle on unaided against the poverty and disease that tormented his declining years. In remarkable contrast to Ewald's poetical works, stand his prose compositions, some of which, such as his *Project Concerning Old Bachelors*, exhibit great powers of comic humour and pleasant raillery, all the more noteworthy when we remember the circumstances under which they were produced. In this respect the case of Ewald presents a striking analogy to the early literary history of J. P. Richter in Germany, and the later career of our own Cowper; and the analogy between Ewald's case and Cowper's is still more curiously borne out by the fact, that each of these poets was cheered towards the latter end by the sympathy and solicitude of a female friend. The story of Mary Unwin is known wherever the English tongue is spoken; the equally noble and self-sacrificing devotion of Madame Skou, if not so widely known, deserves an equally warm tribute at our hands. Under the roof of this lady, who had latterly devoted all her care and time to his service, Ewald died, March 17, 1781, after a painful and distressing illness of nearly two years. The edition of his works which he was engaged in superintending at the time of death, was not finally completed till 1791. The second edition did not appear till 1814–16. A biography of the poet by Molbech was published at Copenhagen in 1830.

EX, or EXE, a river of England, which rises in a barren tract of land called Exmoor, in the county of Somerset, and after being enlarged by several accessions, passes Tiverton, Exeter, and Topsham, and falls into the English channel at Exmouth, after a course of about 45 miles. It is navigable by vessels of considerable burden to Topsham, 8 miles from its mouth.

EXALTATION OF THE CROSS, a feast of the Roman Catholic Church, held on the 14th September. See CROSS.

EXAMINATIONS are of various kinds, according to the objects in view in conducting them,—such as tuitional, competitive, testing. Of these, the first forms a necessary part of every scheme of education; the second is applied to determine the relative merits and attainments of students; the third, to ascertain whether their acquirements are up to a fixed standard, so as to entitle them to certain degrees, or to fill certain situations. Each of these again may be conducted in several ways; 1. Orally; 2. By written exercises done under inspection in a set time; 3. By original compositions written leisurely at home; 4. By disputations; 5. By a combination of the preceding methods. It is proposed in this article briefly to consider each of these kinds of examinations, to discuss the advantages of the different methods of conducting them, the kind of merit and ability which they are qualified to detect, and their value as tests of men so far as concerns their qualifications for practical life.

1. *Tuitional Examinations.*—A system of tuition necessarily involves a system of examination. The object of a teacher being in general to impart to his pupils a knowledge of facts and principles, with the view of storing their minds and developing their faculties, he must take constant pains to ascertain whether these have been clearly apprehended, which he can do no otherwise than by obliging his pupils to reproduce and apply them. In this reproduction a new set of the pupil's faculties are brought into exercise, and the training which his mind receives in examination is seen to be no less important than the acquisition of knowledge itself. Thus, examinations are in a twofold sense necessary accessories to prelections,—the practical and productive fa-

culties being exercised by the former, as the receptive are by the latter. Hence, some of the peculiar advantages of the catechetical teaching still pursued in one or two of our universities, which blends the lecture and examination after the Socratic method. It will be seen that all the methods of examination are applicable to, and necessary for, the purposes of this kind of examination.

2. *Competitive Examinations.*—Though examinations may be presumed to have been purely tuitional in their origin, their power to call out the emulation of the pupils, and to spur them to diligence in their studies, cannot have been long undiscovered. Thus, examinations which were first the teacher's means of gauging the minds of his pupils, so as to satisfy himself of the success or failure of his instructions, soon passed into competitive struggles for honours and prizes, as rewards of merit, and stimulants to industry. The emulation thus educed gives a teacher a most powerful means of securing the mental progress of his pupils,—a means at the same time which should be used with caution, inasmuch as it is better to foster a love of learning for its own sake, than a desire for it as a means of triumph. Too often the desire for superiority becomes secondary in competitive struggles to the desire of winning the prizes. This is the case to a considerable extent in the English universities, and especially in Cambridge, where the primary design of competitive examinations is to some extent thwarted, in consequence of the discouragement to the cultivation of specialties arising from the requirements for the final examination. However much it is to be regretted, it naturally results from the number and value of the prizes awarded to success, that not a few among the candidates for honours in the English universities regard their time, and labour, and the cost of their tuition as an investment, towards securing their position in life, rather than as a contribution to their mental capital. Besides the exhibitions, scholarships, and fellowships which may now be won by competition at our schools and universities, a new class of prizes has lately been opened to successful competition, viz., appointments in the India civil service; and it is highly probable that the vacancies in the home civil service will ere long be supplied by a similar process. The result of rendering the competitive examination system universal cannot at present be safely speculated upon. The Chinese empire, in which the prizes of literary success have for ages been office, wealth, and power, affords an extreme example, which is far from favourable. It seems as if success in science and literature were reserved for those only who follow them with a generous love, for the pleasures and satisfaction they are capable of affording, and as if nature refused to unlock her secrets to any but those who come to her animated with a simple love of truth,—desiring to know her for her own sake, and not for their personal advantage. But whatever may be the ultimate effect of recent changes on the progress of learning and science, there is no doubt of their numerous advantages, meanwhile, in opening up to the aspiring youth of the humbler classes avenues by which to ascend to a better condition; and at the same time in securing for the public service a class of men on the whole better than it has hitherto obtained.

Testing or Pass Examinations.—These are examinations to determine whether candidates are worthy of admission to a college or university, or to offices to which they have been nominated, or to be promoted from one class to another in schools and universities, or to determine their title to degrees—that is to a public recognition of their having creditably completed a certain course of study. These examinations are usually conducted with much less rigour than the competitive, and in many cases are a mere mockery. Besides these more properly scholastic examinations, all the professions are fenced by tests more or less real, which propose to determine whether the candidates for admission to them possess the minimum amount of knowledge and ability necessary for maintaining the honour and credit of the profession, and for practising in it with safety and benefit to the public.

In addition to the testing or pass examinations to which we are accustomed in our own country, there are others of more universal application in use in various foreign states, which require by law that their subjects should be able to read and spell their mother tongue correctly, to write accurately from dictation, and to know the first three or four rules of arithmetic, and a certain amount of geography, before they are allowed to accept responsible employment of any kind. In Denmark this is called the "Confirmation" examination, and a certificate of having passed it must be presented before even a private employer can engage a servant into permanent occupation. In Germany it is called the "Maturity" examination. Some efforts have been made of late to introduce a similar examination in this country, but the genius of our people seems to be opposed to any such innovation.

Oral Examinations.—Examination *vivâ voce*, in itself the most natural and direct method, in cases where it is admissible, seems of all the methods of examination to be the most satisfactory; and there is little doubt that no examination can be quite satisfactory which is not partly oral. In *vivâ voce* examinations there can be no concealment or deception; where knowledge is clear and matured in the mind of the candidate it cannot fail to appear, and where it is hazy, crude, and glimmering, it cannot fail to be detected. The numberless subterfuges with which ignorance may be cloaked in a written exercise, so as to leave the examiner in doubt, are here unavailing. The crammed man stands at once exposed. "A shot," to use the university phrase, is seen to be "a shot" the moment it is made; and an examiner—himself master of his subject—can rarely fail in a few minutes conversation to detect the height and depth of the candidate's knowledge. Of course, oral examination is impossible in all cases, and recourse must be had to written exercises wherever time and deliberation are required on the part either of the candidate in producing his answers, or of the examiner in forming his judgment—as where it is desired to test the candidate's power of applying principles, his ingenuity in solving problems, his appreciation of the beauties and niceties of language, or powers of composition. But oral examinations are liable to this objection, that they make the candidates nervous, and temporarily incapacitate them for the free use of their knowledge and faculties. This however might be obviated if examinations were always conducted in a courteous and affable manner.

At the English universities examination *vivâ voce* is conjoined with examination by written papers in all but the principal degree examinations, and forms part of all the examinations at the chief colleges. The previous (pass) examination, at both Oxford and Cambridge, is partly oral; and in the recent publication of "Papers relating to the Reorganization of the Civil Service," it will be seen that nearly all who were consulted recommend a *vivâ voce* examination as part of the scheme, and that the reporters have adopted this recommendation. In fact, it is commonly agreed by those best able to form an opinion, that if the choice lay between an examination altogether *vivâ voce* or altogether by written papers, the former should be preferred.

In the last report of the university commissioners for Cambridge, the recommendation of several of the professors and private tutors, that a *vivâ voce* examination should form part of the examination for honours, has been adopted, and a change may soon be expected in accordance with it.

Written Examinations.—The best system of written examinations hitherto devised and put in practice in this country is to be found in the English universities. The

Examinations.

greatness of the prizes in these institutions, and the number of the competitors for them, have long forced the attention of the university authorities to the subject of examinations, and to the best means of securing an impartial and correct classification of the candidates for honours; and, on the whole, though the system is not without drawbacks, it may be said to work satisfactorily. An account of the examination of candidates for mathematical honours at Cambridge will suffice for a general account of written examinations, with all their merits and defects. Every year there are appointed two examiners for the business of examination. These examiners are joined to two moderators, who are usually elected for two years, and the four together form a board of examiners for mathematical honours, the duties being divided among them. The number of subjects professed by first-class men may be set down at twenty-five, and on these there are set in all sixteen papers, about three-fourths of which are on what is called "book-work"—or the principles of the sciences, and the remainder on their application; and of late it has been usual to accompany every piece of book-work by a "rider," or simple problem or theorem, the solution or proof of which will test the candidate's apprehension of the principle and his ingenuity, enabling the examiners to discern whether his judgment as well as his memory has been exercised in his reading. The problems are always "made up" for the occasion, and are of all shades of difficulty. To each question, rider, and problem, a number of marks are assigned, according to an average agreed upon by the examiners, and a specified time, generally from two to three hours, is allowed for each paper. He is held to have done best in the examination who has won most marks in the time, and, after him, the rest are classed in the order of their marks. The examination may be said to be on the whole a fair test of mental quickness, of memory, clearness of apprehension, judgment in seizing on the point of a question, and rapidity in penmanship;—in fact, it may be said to test intellectual agility and clear-headedness directly, while indirectly it tests to a degree the powers of application, and the carefulness of students in their studies, and thus, in some measure, both their habits of life and thought. It may be conceived that success in such a struggle must be the triumph of dogged perseverance, united to genuine ability; and this is the case to a considerable extent. In such a competition there is, however, a chapter of accidents of no mean length, and many features more or less repulsive to the best class of minds. Not unfrequently the health and nerves of candidates affect their position in the lists, and they lose in a day the advantage of years. Besides this, the crotchets of the examiners (though by submitting their papers to one another these are to a degree removed) are always more or less marked; and it occasionally happens that *all* the subjects are not done equal or due justice to, and that thus a candidate is deprived of a fair chance, while, at other times, the accidents of the examination place a man far above his true place. Besides these drawbacks, there are others connected with the manner in which the subjects must be "got up" for the contest, and to which the best minds are painfully sensitive. Many things *must* be crammed into the mind which are destined in the nature of them to drop out of it, and which never should have been committed to it; and by this necessity a good man feels more or less degraded. On the whole, however, and these drawbacks notwithstanding, the man of talent who lays himself out to excel in this competition rarely fails in it, at whatever cost to his feelings or damage to his mind. In proof of this, appeal may be made to the university calendar, from which it will appear that for one junior soph who distinguishes himself in after-life, at least twenty wranglers rise to eminence.

The great objection to examinations conducted as above described is, that the candidates are forced to send up answers to questions and solutions to problems written off in great haste, and that they give no chance to that valuable order of mind—the "slow but sure;" the other general objection has already been stated, that by forcing all reading and thought on the part of the candidates to turn towards production in examination papers, it cramps their minds and makes their studies ungenerous. In at least one of the Scotch universities, and in several classes at the rest of them, it is usual to allow an unlimited time for the writing of the papers; but this, while obviating the objection against the haste and flurry of the English system, has a drawback in the absence or laxity of the inspection. The natural supplement to the written examinations in the English universities is the *vivâ voce* and the Essay, which is now to be considered.

Essays.—When the honour of candidates can be relied on, or when, by the other methods of examination, such an approximation to the ability of a candidate has been obtained as may form a check against his practising deception, essays on prescribed subjects done leisurely at home afford a good supplementary test of ability, giving every man a chance of appearing to the best advantage, and obviating alike the hurry of written and the chill of ill-conducted *vivâ voce* examinations.

Disputations.—This method of examination, in which competitors were matched against each other in cross-examination and argument, is now gone into disuse in this country. It still forms a feature in the *Concours* in France, in connection with which it will hereafter be referred to. Its value as an element in an examination affecting to be thorough will be shown in the same connection.

Mixed Examinations.—From what has already been said, it may be gathered that the preceding methods should be conjoined in every examination which aims at a just and impartial classification of candidates according to their real merits and acquirements. That we have in this country no examination even pretending to combine these methods is a matter of reproach, intellectual competitions being so common among us. In the absence of any instance of the mixed examination among ourselves, the combination must be illustrated by an example borrowed from France—viz., the *Concours*—for the admission of members to the medical profession. The *Concours* consists of an assembly of all the members of the medical faculty who can be brought together in the district. Besides these there are the candidates, who, on the occasions of the elections of *élèves internes*, usually number between 100 and 200; and the examination is conducted before a public audience consisting commonly of several hundred persons. The first business is the appointment by ballot of a jury of five of the medical practitioners. A number of skilfully framed and comprehensive questions are then put in a vase, whence one at a time is drawn out by a public officer and given to each of the sets of candidates as they pass in turn to private rooms, where they are kept under inspection. Each set is allowed eight minutes to frame verbal answers to the question which falls to its lot, at the end of which time they return and make their answers before the public. At this stage each candidate is at liberty to question his competitor—cross-examination resulting, which in contests for the higher offices often lead to finished and instructive displays of science and skill. Besides these questions for verbal answers, others of a higher order are put to the sets, to which written answers are required within two hours, the answers being framed as in the former case under inspection. These are delivered sealed, are opened and read by the examiners before the public, and are then submitted for the decision of the jury. The examination is thus continued from day to day, sometimes over a fortnight, till the candidates are thoroughly sifted and the *élite* of them discerned.

Here then are combined the best possible security against partiality on the part of the judges, and the best guarantee that if a man's merits are not detected it must be from some radical defect in himself which mars his better qualities; the *vivâ voce*, the written exercise, and the disputation being here practically combined, before an impartially chosen tribunal.

This account of the *Concours* naturally leads to a consideration of the practical difficulties encountered in competitive examinations in general. These are connected, 1*st*, with the appointment of examiners; 2*d*, with the affixing of marks to the questions, and the adjudging what proportion of the full marks the answers sent up merit. With regard to the first it may be set down as a rule, that in a college or university the prelector should not be the examiner of his own class, and that in any case the same examiner should not be employed on more than one or two occasions. In colleges where professors act as the examiners for their own classes, and in the case of examining boards such as that of the London university—which is virtually a permanent body—students soon discover what questions are considered crucial by the examiners, their crotchets become familiar, and the examination tends to degenerate into a mere test of cramming. The system followed at Oxford and Cambridge, whereby fresh men are annually brought to the task of examination, seems to be the only one in this country free from objection. The permanency of the board of examiners for the India Civil Service is the worst feature in the scheme of reform, and may (acting conjointly with a similiar board for the Home Civil Service) have a very prejudicial effect on the progress of education. Where those who are to decide upon the merits of candidates are previously known, and hold their office permanently, it becomes the interest of the candidate to ascertain their opinions and crochets; and, as a matter of course, he directs his studies to their specialties and standard, rather than to the latest state of scientific information, which, in professional matters especially, is too frequently not the state most favoured by the examiners. And that this is the case may be inferred from the fact that a body of crammers is always to be found drilling men successfully for examination by all such permanent examiners, whose habitual routine of questions they make a business of ascertaining, preparing their pupils to answer them and them only. Whereas, when the examiners are varied from year to year, as at the English universities and in the French *Concours*, a candidate can only expect to win his way by sedulous attention to the entire course of his study, and by availing himself of every opportunity of gaining the latest and best authenticated information on the subjects allied to it. The difficulty connected with the appointment of examiners will be seen to be one of expense; and if the weight of the objections to the present arrangement in our Scotch universities, as well as to the proposed permanent boards for the civil services, were duly appreciated, there is no reason why they should not at once be removed. Regarding the difficulty connected with the affixation of marks to the papers of the respective candidates, there appears to be no remedy; merit must remain, within certain limits, a matter of opinion. It is plain that short of omniscience on the part of the examiners, the distribution and affixation of marks cannot be accomplished with any great degree of accuracy, and all that can be expected is, that the examiners being honourable men, will take due care in the performance of their task, and satisfy their own judgments and consciences that they have to their best ability faithfully discharged it.

The growing importance which is being attached to examinations in literary and scientific subjects as tests of qualifications for practical life, makes it necessary that a few words be said here on their value as tests of such qualifications. It will be admitted by all who have had to do extensively with examinations and the education of youth, that, however useful examinations may be in ascertaining the special *acquirements* of men, they are nowise certain to detect the man of real talent, endowed with practical good sense, and with ability to conduct himself with propriety and decision under new and unexpected combinations of circumstances. At the age when examinations are entered into, it often happens that a man fails because his intellect has not fully developed itself, and as often that a sickly precocity bears off the palm. Not unfrequently, too, men win prizes at competitive examinations who have, under the influence of a strong hope or fear, laboured hard at their studies, and who, the moment the motives which urged them to exertion are removed, collapse into spiritless indolence—a case of common occurrence in the English universities; while, on the other hand, a man of sturdy fixed principle, being, it may be, above the considerations which actuated his contemporaries, passes into life in possession of healthy and not overtaxed faculties, finding in practical affairs motives to exertion which he failed to find in the world of scholarly ideas. Besides, unless a man has been previously tried in practical life, an examination will not ascertain, or will only ascertain imperfectly, the qualifications of industry, punctuality, correctness in the transaction of business, steadiness or reliability, or the power of fixing the attention immediately and steadily on new work. But these are the very qualities necessary for success in practical life. And as these observations are made with special reference to the proposed reforms in the civil service, the experience of that service in past times may be quoted in proof of the preceding view. In this service it has been found, that even first-class men from Oxford and Cambridge have proved failures in as large proportion of instances as any others, —the failures arising both from unsuitable qualifications, and from holding themselves above the valuable steady labour, called "drudgery," required in subordinate appointments, and above applying zealously such general qualifications as they may possess. This experience raises an objection to every scheme for the appointment of public servants which proposes to apply to them academic tests alone. If at present learning, science, and scholarly accomplishments have little or no weight in determining appointments, the practical qualities which directly fit a man for the business of life are in danger of being overlooked under the new system. This danger is heightened by the consideration, that the best men, who are generally ambitious, are not likely to offer themselves as candidates for such meagre appointments as those of the subordinate offices in the civil service (where the prospect of rapid promotion is so very small), but will prefer the more open, though more hazardous, competitions of professional life; and thus the choice for the civil service may lie between the men of middle-rate intellect, as displayed in academic pursuits, and the men of "unadorned" business talent, over whom, however, the mediocre class of scholars are sure to be preferred in the academic contest. The loss to the service may thus prove to be greater than the gain contemplated in the proposed "improvement." And while it is easy to run up a long list of eminent scholars, who, after leaving the schools and universities, distinguished themselves in public life,—such as Hastings, Metcalfe, Wellesley, Law, Ellenborough, Mansfield, Eldon, Stowell, Gibbs, Tindal, Tenterden, Lyndhurst, and a host of others of recent date, or who are still famous; it must not be forgotten, that if the entrance to public life had always been guarded by academic tests, more than one lord chancellor and chief justice who rose from being attorneys' clerks, would have been excluded from the service of their country, which would also have lost many others of its most famous men by the same means. The present commander-in-chief began his military career when about twelve years of age; and the late Duke of Wellington used to declare, that an academical education would have ex-

cluded him from the army, as it certainly would have excluded Nelson from the navy. It is useless, however, to balance names in such an argument; it is sufficient to appeal to the reader's own experience, whether he has not known cases of success from small and rough beginnings, numerous enough to convince him that scholarly accomplishments have little to do with qualifying a man for practical affairs. More than one instance might here be cited of engineers who commenced their professional lives with wheelbarrows in hand, overcoming difficulties before the close of their careers which academies of science had declared to be insuperable. There is little doubt that men of this class, if educated in academic fashion, would have distinguished themselves in intellectual competitions. But the question is, what countervailing advantage would they have derived from having been put to these studies, at the expense of several years spent at a university, instead of being engaged during that period in the practical work of life. The balance is to be struck between the advantages, so far as regards eventual efficiency, of four or five years spent at a university in the cultivation of accomplishments, and the same number spent in actual practice in the world. The advantage of scholarship and scientific knowledge to a man himself, must be wholly left out of this consideration; and when this is done, it will be found extremely difficult to come to a decision, considering how often eminence in that which is of little practical use is found to have been attained to the exclusion of that which is practically the most needed. Indeed, the popular prejudice against scholars and men of science, as regards their fitness for business, is not altogether without foundation; and many instances might be quoted to show, that a minute knowledge of the niceties of language, and habits of reasoning accurately *from* abstractions *to* abstractions, are far from being the best guarantees of practical ability. Mr Laing remarks, that the manner in which the French and German philosophers conducted the great public interests and affairs entrusted to them in 1848, "shows that the mind formed in literary pursuits is not the best prepared to deal with men and realities in social economy or in affairs of state. It is not a matter of course that the eminent literary man, philosopher, professor, or author, must be a good minister of state, or a great financier, or even a man of practical views, unshaken steadiness, and of reliability and political honesty. The history of Germany, and France since 1848, has not raised the character of literary men in the field of politics, or proved that they are not in their right places in their libraries and class-rooms."—(*Observations on the Social and Political State of Denmark, &c.*, 1852.)

These considerations indicate the necessity for devising a test of qualifications more thorough than has yet been invented. It is abundantly clear, that the academic test should not be held sufficient of itself; and it appears that a modification of the plan at present proposed for the election of civil servants should be made, and that a moderate academic test should be applied to the candidates *at an early age*, a term of probation being fixed between the nomination subsequent to the examination, and the final confirmation of the appointment. (J. F. M'L.)

EXARCH (ἔξαρχος, *a chief person or leader*), a title that has been conferred at different periods on certain chief officers or governors, both in secular and ecclesiastical matters. Of these, the most important were the exarchs of Ravenna. The first of these was appointed by Justinian, emperor of the East, as governor of the middle part of Italy, which was made a province of the Eastern empire after Narses had entirely subdued the Goths and their allies in Italy, A.D. 552–554. Ravenna, with the whole exarchate, was conquered by Astolphus, king of the Lombards, in the year 752; but three years later it was taken by Pepin, king of the Franks, who bestowed it on the pope (Stephen III.),—since which time Ravenna and its territory have remained united to the papal dominions.

Exarch of a Diocese was, anciently, the same with primate. This dignity was intermediate between the patriarchal and the metropolitan. *Exarch* is also used, in the ecclesiastical antiquities of the Eastern Church, for a general or superior over several monasteries.

In the modern Greek Church, an exarch is a deputy or legate *a latere* of the patriarch, whose office it is to visit the clergy and churches in the provinces allotted him. The power which the exarch enjoys, and the uses to which he turns it, recall the times of the corrupt proconsulars of the Roman empire. He usually enriches himself greatly in his post, and frequently rises to the patriarchate itself.

EXAUCTORITAS, in the ancient Roman military discipline, denoted a partial discharge from service, granted to those soldiers who had served in the legion for sixteen years, and who were thus said to become *exauctorati*, though they continued, under a *vexillum* or standard of their own, in company with that legion, until they had completed their full term of service, namely, twenty years, after which they received the *missio* or full discharge. After the Augustan period, the term *exauctorare* was used to signify a simple discharge, and also to denote a cashiering on account of misconduct—in which last sense alone it was employed during the period of the decline.

EXCAMBION, from the Italian *Cambio, exchange*, is the name given, in Scots law, to the contract by which one piece of land is exchanged for another. The deeds by which this contract is completed, must expressly bear that the lands are mutually given in excambion. In such deeds a real warrandice of the lands excambed is implied, so that in the case of eviction of either party from the land which he has received in excambion, he may recover possession of that which he gave in exchange. This warrandice holds good not only with the contracting parties but also with their heirs and singular successors. This species of contract is resorted to for straightening the marches of contiguous lands.

EX CATHEDRA, a Latin phrase, originally applied to the dictates or decisions of prelates, chiefly popes, delivered in their pontifical capacity. Hence, in common language, it is applied to any decision or order given with an air of official authority.

EXCELLENCY, as a title of honour, was anciently given to kings and emperors. Charlemagne, for instance, was sometimes thus styled. The title was likewise accorded to the Venetian senate; and in earlier times to the exarchs, &c. It is now restricted, for the most part, to ambassadors and commanders-in-chief. The governors of some provinces are also styled *excellency* if they have no other title; but if they be peers or right honourable, they take the honorary title belonging to their position. In the United States of America, the president, the ministers plenipotentiary to foreign countries, and the governors of states, all claim the title of *excellency*.

EXCENTRIC, deviating from the centre; not having the same centre. The term is applied in geometry to circles and spheres which have not the same centre, and consequently are not parallel; in opposition to concentric, where one surrounds the other ring-wise.

EXCENTRICITY, in *Astronomy*, the distance of the centre of the orbit of a planet from the centre of the sun; that is, the distance between the centre and the focus of the ellipse in which the planet moves.

EXCHANGE.

Exchange.

In commercial economy the term "Exchange" is commonly employed to designate that description of mercantile transactions, by which the debts of individuals residing at a distance from each other are liquidated, without the intervention of money. The object of this article is to explain the nature of these transactions, and the principles on which they depend.

This will be best effected by treating, *first*, of the exchange between different parts of the same country; and, *secondly*, of that between different and independent countries.

Inland exchange.

Inland Exchange.—Suppose a merchant of London orders his agent in Glasgow to send him a thousand pounds' worth of cottons, and that it does not suit the agent to commission goods of equal value from his London correspondent, the latter may, notwithstanding, be under no necessity of remitting cash to Glasgow in discharge of his debt. Among countries or cities having a considerable intercourse together, the debts mutually due by each other are found, in ordinary cases, to be nearly equal. The Glasgow agent, who has shipped the cottons for London, does not, therefore, transmit the bill drawn by him on his correspondent for their price to London to be cashed, as that would subject him to the expense of conveying the money home to Glasgow; but he gets its value from some other party in Glasgow, who has a payment to make in London on account of tea or some other article bought in that city, and who, unless he could procure such a bill, would be obliged to remit its price in money. The bill on account of the cottons is, therefore, either drawn in favour of the party in London who furnished the tea, or it is drawn in favour of the tea-dealer in Glasgow, and indorsed by him to the former, who, on presenting it to the purchaser of the cottons, receives its value, and consequently the price of the cottons, and the price (or part of the price) of his tea, at the same moment. This simple contrivance obviates the expense and risk attending the transmission, first, of money from London to Glasgow to pay the cottons, and, second, of money from Glasgow to London to pay the tea. The debtor in one is changed for the debtor in the other; and both accounts are settled without the intervention of a single farthing.

The bill drawn and negotiated in such a transaction as this is termed an *inland* bill of exchange. If the transaction had taken place between London or Glasgow and a *foreign* city, it would have been termed a *foreign* bill of exchange.

A bill of exchange may, therefore, be defined to be, "an order addressed to some person residing at a distance, directing him to pay a certain specified sum to the person in whose favour the bill is drawn, or his order."[1]

The price of bills fluctuates according to their abundance or scarcity compared with the demand. If the debts reciprocally due by London and Glasgow be equal, whether they amount to L.100,000, L.500,000, or any other sum, they may be discharged without the intervention of money, and the price of bills of exchange will be at PAR; that is, a sum of L.100 or L.1000 in Glasgow will purchase a bill for L.100 or L.1000 payable in London, and *vice versa*. But if these cities be not mutually indebted in equal sums, then the price of bills will be increased in the city which has the greatest number of payments to make, and reduced in that which has the fewest. If Glasgow owe London L.100,000, whilst the latter only owes the former L.90,000, it is clear, inasmuch as Glasgow has a larger sum to remit to London than London has to remit to Glasgow, that the price of bills on London will rise in Glasgow because of the increased demand, and that the price of bills on Glasgow will fall in London because of the diminished demand. A larger sum would consequently be required to discharge a debt due by Glasgow to London, and a less sum to discharge an equal debt due by the latter to the former; or, which is the same thing, the exchange would be in *favour* of London, and *against* Glasgow. Bills on London would sell in Glasgow at a *premium*, and bills on Glasgow would sell in London at a *discount;* the premium in the one case being equal to the discount in the other.

On the supposition that the balance of L.10,000, due by Glasgow, depresses the exchange on London *one per cent.*, it appears, at first sight, that it will cost Glasgow L.101,000 to discharge her debt of L.100,000 due to London; and that, on the other hand, L.89,100 would be sufficient to discharge the debt of London to Glasgow. But a very little consideration will serve to show that this would not be the case. Exchange transactions cannot take place between different cities until debtors and creditors of the one reside in the other. And hence, when the exchange became unfavourable to Glasgow, the premium paid by its merchants for bills on London would not go into the pockets of their creditors in the latter, but into those of their neighbours in Glasgow to whom London was indebted, and from whom the bills were purchased. The loss to Glasgow would, therefore, be limited to the *premium* paid on the balance of L.10,000. Thus, supposing that A of Glasgow owes D of London L.100,000, and that C of London owes B of Glasgow L.90,000; A will pay to B L.91,000 for a bill or order on C to pay D L.90,000. In this way the L.90,000 of London debt at Glasgow would be cleared off; the premium, which is lost by the debtor to London in Glasgow, being gained by its creditor in the same place. If the business had been transacted in London, C, with L.89,100, would have purchased of D a bill for L.90,000, payable by A; so that, in this case, the gain would have fallen to the share of the debtor C, and the loss to that of the creditor D, both of London. The complexity of real transactions does not affect the principles on which they are founded. And whatever may be the amount of the debts reciprocally due by different places, the only disadvantage under which any of them could be placed by a fall of the exchange would be the unavoidable one of paying the expense of remitting the *balance* of debt.

The expense of transmitting money from one place to another limits the fluctuations in the exchange between them. If 20s. sufficed to cover the expense and risk attending the transmission of L.100 from Glasgow to London, it would be indifferent to a merchant, in the event of the exchange becoming unfavourable to the former, whether he paid one per cent. *premium* for a bill on London, or remitted money direct to the latter. If the premium were less than one per cent., it would be clearly his interest to make his payments by means of bills rather than by remittances; and that it could not exceed one per cent. is obvious, for every

[1] In mercantile phraseology, the person who draws a bill is termed the *drawer;* the person in whose favour it is drawn, the *remitter;* the person on whom it is drawn, the *drawee*, and after he has accepted, the *acceptor*. Those persons into whose hands the bill may pass previously to its being paid, are, from their writing their names on the back, termed *indorsers;* and the person in whose possession the bill is at any given period, is termed the *holder* or *possessor*.

individual would rather directly remit money than incur an unnecessary expense by purchasing bills on London at a greater *premium* than would suffice to cover the expense of a money remittance. If, owing to the badness of roads, disturbances in the country, or any other cause, the expense of remitting money from Glasgow to London were increased, the difference in the rate of exchange between them might also be proportionally increased. But in every case the extent to which this difference could attain would be limited by, and could not for any considerable period exceed, the cost of remitting cash.

Exchange transactions become more complex when one place, as is often the case, discharges its debts to another by means of bills drawn on a third place. Thus, though London should owe nothing to Glasgow, yet if Glasgow be indebted to London, London to Manchester, and Manchester to Glasgow, the latter may wholly or partially discharge her debt to London by remitting bills on Manchester. She may wholly discharge it, provided the debt due to her by Manchester exceed or is equal to the debt due by her to London. If, however, it be not equal to the latter, Glasgow will either have to remit money to London to pay the balance of debt, or bills on some other place indebted to her.

Transactions in inland bills of exchange are almost entirely conducted by bankers, who charge a certain rate per cent. for their trouble, and who, by means of their credit and connections, are able, on all occasions, to supply the demands of their customers. London, because of its extensive correspondence with other parts of the country, occasioned partly by its immense commerce, partly by its being the seat of government and the place to which the revenue is remitted, and partly by its currency consisting of Bank of England paper, for which the notes of the country banks are rendered exchangeable, has become the grand focus in which the money transactions of the United Kingdom centre, and in which they are all ultimately adjusted. These circumstances, but especially the demand for bills on London to remit revenue, and the superior value of Bank of England paper, render the exchange between London and other parts of the country invariably in her favour. Bills on London drawn in Edinburgh and Glasgow were formerly made payable at forty days' date, which was equivalent to a *premium* of about $\frac{1}{2}$ per cent; but, owing to the greater facility of communication, this *premium* is now reduced to twenty days' interest, or to about $\frac{1}{4}$ per cent. Bills for remitting the revenue from Scotland are now drawn at thirty days; previously to 1819 they were drawn at sixty days.

These statements are sufficient to show that, how well soever bills of exchange may be fitted for facilitating the operations of commerce, and saving the trouble and expense attending the transportation of money, mercantile transactions cannot be adjusted by their means except in so far as they mutually balance each other. A *real* bill of exchange is merely an order entitling the holder to receive payment of a debt due by the person on whom it is drawn. It is essential to the existence of such bill that an equivalent amount of debt should be contracted. And hence, as the amount of the real bills of exchange drawn on any number of merchants cannot exceed the amount of their debts, if a greater sum be owing by them than they owe to others, the balance must either be paid in money or by the delivery of some sort of commodities. If, as in the case referred to, Glasgow owe London L.100,000, while London only owes Glasgow L.90,000, a reciprocal transfer of debts may be made to the extent of L.90,000. But the Glasgow merchants cannot discharge the additional L.10,000 by means of bills on London; for, by the supposition, London only owed them L.90,000, and they have drawn for its amount. This balance must therefore be discharged by an actual money payment, or by the delivery of some species of produce, or by bills on some third party indebted to Glasgow.

It is not meant by this to insinuate that *fictitious* bills of exchange, or bills drawn on persons who are not really indebted to the drawer, are either unknown or very rare. In commercial countries bills of this description are always to be met with; but they are a device for obtaining loans, and cannot transfer real debts. A of London may form a connection with B of Glasgow, and draw bills upon him payable a certain number of days after date, which the latter may retire by selling bills upon A. The merchants who purchase, or the bankers who discount these bills, advance their value to the drawers, who, by means of this system of *drawing* and *redrawing*, command a borrowed capital equal to the amount of the fictitious paper in circulation. It is clear, however, that the negotiation of such bills cannot assist in transferring and settling the *bona fide* debts of two or more places. Fictitious bills mutually balance each other. Those drawn by London on Glasgow equal those drawn by Glasgow on London, for the one set is drawn to pay the other—the second destroys the first, and the result is nothing.

The raising of money by means of fictitious bills has been severely censured by Adam Smith, who says it entails a ruinous expense on those engaged in it, and is resorted to only by projectors, or persons of suspicious credit. When fictitious bills are drawn at two months' date, it is common to charge, in addition to the ordinary interest, a commission of half or quarter per cent., which must be paid every time the bill is discounted, or, at least, *six* times a-year. The total expense of money raised in this way could not, therefore, supposing the transaction to be always on account of the same individual, and interest 4 per cent., be estimated at less than $5\frac{1}{2}$ or 7 per cent. per annum, *ex* stamps; and the payment of so high an interest on borrowed capital, in a country where the ordinary rate of mercantile profit is not supposed to average more than from *six* to *eight* per cent., could not fail to be frequently productive of ruin to the borrower. But it seldom happens that, in the negotiation of fictitious bills, the charge for commission falls on one individual only. Loans obtained in this way are usually on account of two or more parties. At one time a fictitious bill is drawn by A of London on B of Glasgow; and, in this case, the latter will, before the bill becomes due, draw upon A for its amount, including interest and commission. At another time, the transaction will be on account of B, who in that case has to pay commission to his friend in London; so that each party may, on the whole, as Mr Thornton has observed, gain about as much as he pays in the shape of commission.

It is often extremely difficult to distinguish fictitious bills from those which have arisen out of real transactions. Neither does it seem to be of any very material importance. The character and credit of the parties whose names are attached to bills, are the only criteria by which merchants or bankers can judge whether they ought to negotiate them. The circumstance of an individual offering accommodation paper for discount, ought unquestionably, if it be known, to excite suspicions of his credit. But unless in so far as the drawing of fictitious bills may be held to be indicative of overtrading, or of a deficiency of capital to carry on the business in which the party is engaged, there does not appear to be any very good reason for refusing to discount them.

Within the last few years, it has been the practice to grant money orders, payable on presentation at the different post-offices, for sums of L.5 and under. These orders cost 3d. for sums of L.2 and under, and 6d. for sums between L.2 and L.5 inclusive; and as they are not paid unless the parties in whose favour they are drawn, or other parties well known to the postmasters by whom they are payable,

Exchange.

appear to receive payment, there is no risk of the money getting into improper hands. This system has been found to be a very great accommodation to the public, especially to those having small sums to remit, and has been very extensively resorted to. In 1850, 4,439,713 money orders were issued in the United Kingdom; the aggregate sum transferred by their agency being L.8,494,498, 10s. 7d.

These observations will, perhaps, suffice to explain the manner in which transactions between different parts of the same country are settled by means of bills of exchange. They are, in general, extremely simple. The uniform value of the currency of a single country renders unnecessary any comparison between the value of money at the place where the bill is drawn and negotiated, with its value where it is to be paid; while the constant intercourse maintained amongst different parts of the same kingdom, and the usual absence of those occurrences by which the intercourse between distant and independent countries is always subject to be interrupted, prevent those sudden fluctuations which frequently arise in the prices of foreign bills of exchange. We shall, therefore, leave this part of our subject, and proceed to investigate the circumstances which influence the course of exchange between different and independent countries.

Foreign exchange.

Foreign Exchange.—The price of foreign bills of exchange depends on two circumstances: *first*, On the value of the currency of the place where they are made payable, compared with the value of the currency of the place where they are drawn; and, *secondly*, On the relation which the supply of bills in the market bears to the demand.

If the value of the different coins and moneys which circulate in nations having dealings with each other were invariable, the exchange would be exclusively influenced by circumstances affecting the supply and demand for bills. But, in addition to variations in its cost in particular countries, the weight and fineness of the bullion contained in their coins are liable to all sorts of variations. And it is almost needless to say, that the price of bills, as of everything else, necessarily varies with these variations, increasing when the value of the money in which they are estimated falls, and falling when it increases. But these, it is plain, are merely nominal or numerical variations. They grow out of changes in the standard employed to measure values, and not in the values themselves. It is otherwise, however, with variations of price occasioned by changes in the supply of bills, or in the demand for them; that is, by changes in the payments a country has to make compared with those it has to receive. These are real, not nominal variations, for they affect the values in bills, and not the money in which these values are expressed. And hence the distinctions of *nominal, real,* and *computed* exchange. The *first* depends on alterations in the value of the currencies compared together; the *second* depends on the supply of bills in the market compared with the demand; and the *third*, or *computed* exchange, depends on the combined effects of the other two. For the sake of perspicuity we shall treat of these separately.[1]

Sect. I.—*Nominal Exchange.*

Bullion being everywhere recognised as the standard currency of the commercial world, the comparative value of the currencies of particular countries depends—1*st*, On the value of bullion in those countries; and, 2*dly*, On the *quantity* of bullion contained in their coins, or on the quantity of bullion for which their paper money, or other circulating media, will exchange.

Nominal exchange.

1. The value of freely produced commodities being commonly proportioned to the *cost* of their production, including therein the cost of their conveyance from where they have been produced to where they are to be made use of, it follows, were the trade in the precious metals perfectly open, and the commodities produced in different countries about equally well fitted for exportation, that the value of bullion in one, compared with its value in another, would be chiefly determined by their respective distances from the mines. Thus, on the supposition that neither England nor Poland had any article except corn to exchange with the Americans or Australians for bullion, it is evident that the precious metals would be more valuable in Poland than in England, because of the greater expense of sending so bulky a commodity as corn the more distant voyage, and also of the somewhat greater expense of conveying the gold to Poland. Had Poland succeeded in carrying her manufactures to a higher pitch of improvement than England, her merchants might be able, notwithstanding the disadvantage of distance, by exporting commodities possessed of great value in small bulk, the freight of which would be comparatively trifling, to buy bullion on cheaper terms than those of England. But when, as is actually the case, the advantages of skill and machinery are on the side of England, another reason is added to that derived from our less distance from the mines, why gold and silver should be less valuable here than in Poland, and why the money price of commodities should be higher.[2]

Hence, among nations which have attained to different degrees of excellence in manufacturing industry, the value of bullion does not wholly depend on their distance from the mines. But, whatever variations a different progress in the arts may occasion in its value in different countries, it is always less valuable in those into which it is imported, than in those in which it is produced. Like everything else, it is exported to find, not to destroy, its level. And unless its value in Europe exceeded its value in America and Australia by a sum sufficient to cover the expense of its importation, including ordinary profits to the importers, we should not, though the mines in these quarters were infinitely more productive, import from them a single ounce of bullion in the ordinary course of trade. It is obviously incorrect, therefore, to lay it down as a general proposition, "that the par of exchange between two countries is that sum of the currency of either of the two, which, in point of intrinsic worth, is precisely equal to a given sum of the other; *that is, contains precisely an equal weight of gold and silver of the same fineness.*"[3] For a given quantity of gold and silver is not always, as is here assumed, of the same intrinsic value in different countries. It may differ but little among nations bordering upon or near each other, and which are all destitute of mines. But though, to use a familiar illustration, the value of sugar approaches nearly to a level in the great trading cities of Europe, it cannot surely be maintained that its value in the West Indies is as great as in Bordeaux or Liverpool, or that the exchange would be really at par, if a bill, which cost a hundred hogsheads of sugar in London, only brought a hundred in Jamaica. Now, in respect of principle, this is precisely the case with bullion. Though the values of gold and silver, compared with corn, labour, &c., may, and indeed must, vary very considerably among different nations, these variations are only the necessary result of their different progress in industry, and of the different quality of their cultivated lands, &c. Such differences of price are in the natural order of things; and bullion has not found its proper level till a quantity has been introduced into those countries which excel in manufactures, sufficient to raise the price of their

[1] Supposing every country to be in possession of its proper supply of bullion, the exchange may be said to be *nominally* affected by the amount of the difference between the market and mint price of bullion, and to be *really* affected by any deviation from par exceeding or falling short of that difference. [2] Ricardo, *Principles of Political Economy*, &c., first ed., p. 175. [3] *Bullion Report*, p. 22, 8vo ed.

Exchange. corn and labour. These variations have, therefore, no influence over the exchange. Notwithstanding this difference of price, an ounce of bullion in one country, owing to the facility of intercourse, is very near equivalent to an ounce of bullion in another; and, supposing the trade in the precious metals to be perfectly free, the exchange will be at true par when bills are negotiated on this footing. But when we compare the values of these metals in distant countries, especially in those where they are produced, with those into which they are imported, there are very considerable differences. Gold and silver, like iron, coal, tin, &c., are necessarily cheaper in countries possessed of extraordinarily productive mines, than in those possessed only of mines of a secondary degree of fertility, or where they have to be entirely brought from abroad. And the exchange between such places is not a true par, unless adequate allowance be made for this difference of value. Thus if, because of the expense of carriage, the value of bullion in Great Britain be 5 per cent. greater than in San Francisco, 100 ounces of pure gold in the latter would not be worth 100 ounces of pure gold in London, but 5 per cent. less; and the exchange would be at true par when bills for 105 ounces standard bullion, payable in San Francisco, sold in London for 100 ounces.

The different values of the precious metals in different countries do not depend alone on their respective distances from the mines, or on their greater or less progress in the arts. The opinion formerly so very prevalent, that gold and silver were the only real wealth, led most nations to fetter and restrain their exportation, and to adopt a variety of measures intended to facilitate their importation. But these, even when most vigorously enforced, were singularly ineffectual. The great value and small bulk of the precious metals rendered it not only advantageous, but comparatively easy, clandestinely to export them, whenever their relative value declined.

"When," says Adam Smith, "the quantity of gold and silver imported into any country exceeds the effectual demand, no vigilance of government can prevent their exportation. All the sanguinary laws of Spain and Portugal are not able to keep their gold and silver at home. The continual importations from Peru and Brazil exceed the effectual demand of those countries, and sink the price of those metals there below that in the neighbouring countries. If, on the contrary, in any particular country their quantity fell short of the effectual demand, so as to raise their price above that of the neighbouring countries, the government would have no occasion to take any pains to import them. If it were even to take the pains to prevent their importation, it would not be able to effectuate it. Those metals, when the Spartans had got wherewithal to purchase them, broke through all the barriers which the laws of Lycurgus opposed to their entrance into Lacedæmon. All the sanguinary laws of the customs are not able to prevent the importation of the teas of the Dutch and Gottenburg East India Companies, because somewhat cheaper than those of the British Company. A pound of tea, however, is about a hundred times the bulk of one of the highest prices, 16s., that is commonly paid for it in silver, and more than two thousand times the bulk of the same price in gold, and consequently just so many times more difficult to smuggle."[1]

But, though ineffectual to prevent their egress, the restrictions on the exportation of the precious metals have nevertheless contributed to occasion some slight variations in their value in different countries. The risk formerly incurred by the clandestine exporters of bullion from Spain, is supposed to have been equivalent to about two per cent.; or, which is the same thing, it is supposed that the restrictions maintained such an excess of gold and silver in that country as to sink them two per cent. below their value in countries having a free trade in bullion. In calculating the true par of exchange between different countries, circumstances of this kind must be taken into account. For, to whatever extent bullion in one country may be sunk below its value in those with which it maintains an intercourse, the nominal exchange will necessarily be unfavourable to that extent.[2] Exchange.

It consequently results, that whatever occasions a rise or fall of the value of the precious metals in one country affects to the same extent its nominal exchange with other countries. If more coin, or convertible paper, circulated in Great Britain, compared with the business it has to perform, than in other countries, its relative value would be proportionally less. Foreign bills would sell for a premium, the amount of which would measure the excess of the value of the precious metals in the foreign market, caused by their redundancy in the home market. And, on the other hand, in the event of our currency becoming relatively deficient, its value would be proportionally increased; bills drawn on foreign countries would sell at a discount, the amount of which would equal the excess of the value of our currency over that of other countries.

2. In estimating the quantities of bullion contained in the coins of different countries, a particular coin of one, such as the British pound sterling, is selected for a standard by which to compare the others, and the proportion between it and them, supposing them to be all of their standard weight and fineness, is ascertained by experiment. A par of exchange is thus established, or rather it is ascertained that a certain amount of the standard currency of one country contains as much gold or silver of the same fineness, as is contained in the coin or integer with which it has been compared. This relation, or *par*, as it is technically termed, is considered invariable; and allowance is made for subsequent variations in the coins of countries trading together, by rating the exchange at so much above or below par. In mercantile language, that country, by a comparison with one or other of whose coins the par of exchange has been established, is said to give the *certain* for the *uncertain*, and conversely. Thus, in the exchange between London and Paris, London and Hamburg, &c., London gives the *certain*, or the pound sterling, for an *uncertain* or variable number of francs, florins, &c. Hence, the higher the exchange between any two countries, the more is it in favour of that which gives the *certain;* and the lower, the more is it in favour of that which gives the *uncertain*.

Par of exchange.

On the supposition that 25 francs contain the same quantity of standard bullion as a pound sterling (25 fr. 57 cent. is about the exact par), and supposing also that the value of bullion is the same in both countries, the exchange between London and Paris will be at par when a bill drawn in the one on the other sells at that rate; that is, when a bill of exchange for 2500, or 25,000 francs, payable in Paris, sells in London for L.100 or L.1000, and *vice versa*. It is but seldom, however, that the coins of any country correspond exactly with their mint standard. Unless when newly issued, they are either more or less worn; and whenever this defect becomes sensible, an allowance corresponding to the difference between their actual value and their mint value is made in estimating "the sum of the existing currency of either of two countries which contains precisely the same quantity of bullion as is contained in a given sum of the other." Thus, if our pound sterling were so worn,

[1] *Wealth of Nations*, p. 190.

[2] All restraints on the exportation of the precious metals were abolished in Great Britain in 1819. Their effect for many years previously could notestimated at above one-fourth per cent.

Exchange.

clipped, or rubbed, as not to contain so much bullion as 25 fr., but 10 per cent. less, the exchange between London and Paris would be at real par when it was nominally 10 per cent. against London;[1] and if, on the other hand, the pound sterling were equal to its mint standard, while the franc was 10 per cent. less, it would be at par when it was nominally 10 per cent. against Paris and in favour of London. If the currencies of both countries were equally reduced below the standard of their respective mints, there would obviously be no variation of the par; but whenever the currency of countries trading together is unequally depreciated, the exchange is nominally in favour of that country whose currency is least, and nominally against that whose currency is most, depreciated.

It is almost unnecessary to refer to examples to show the practical operation of this principle; and we shall content ourselves with selecting the following, from an infinite number of equally conclusive instances.

Previously to the great recoinage in the reign of William III., silver being at the time legal tender, the exchange between England and Holland, calculated by the standard of their respective mints, was nominally twenty-five per cent. against England. Inasmuch, however, as English silver coins were then, owing to rubbing and clipping, depreciated more than twenty-five per cent. below their mint value, the real exchange was probably at the time in our favour. And the circumstance of the nominal exchange having become favourable to us as soon as the new coin was issued, tends to confirm this conjecture.[2]

The guinea was so much worn and degraded, previously to the gold recoinage in 1774, as to be from 2 to 3 per cent. under its standard weight. Inasmuch, however, as the coins then circulating in France were nearly of their standard weight and purity, the exchange between London and Paris was nominally from 2 to 3 per cent. against the former. We say *nominally*, for as soon as guineas of full weight were issued, the exchange rose to par.

The Turkish government, during the past century, has made successive reductions in the value of its coin. Before the first of these in 1770, the *piastre* contained nearly as much silver as the English *half-crown;* and, in exchange, the par was estimated at *eight* piastres to the pound sterling. But, in the interval, the degradation in the value of the piastre has been such that it is now worth only about $2\frac{1}{4}$d.; and the exchange is said to be at par when Constantinople gives about 109 piastres for L.1 sterling. It is needless almost to say, that the nominal exchange, estimated by the old *par* of eight piastres to L.1, became more and more unfavourable to Turkey with every successive enfeeblement of the coin, though it is doubtful whether the real exchange, or that depending on the balance of payments, was not all the while in her favour.

When one country uses gold as the standard of its currency, and another silver, the par of exchange between them is affected by variations in the relative values of these metals. When gold rises as compared with silver, the exchange becomes nominally favourable to the country which has the gold standard, and *vice versa.* And hence, in estimating the par of exchange between countries using different standards, it is always necessary to inquire into the comparative values of the metals selected for standards.

"For example," to use the words of Mr Mushet, "if 34 schillings 11 grotes and $\frac{1}{4}$ of Hamburg currency be equal in value to a pound sterling, or $\frac{20}{21}$ of a guinea, when silver is at 5s. 2d. per oz., they can no longer be so when silver falls to 5s. 1d. or 5s. an oz., or when it rises to 5s. 3d. or 5s. 4d.; because a pound sterling in gold being then worth more or less silver, is also worth more or less Hamburg currency.

"To find the real par, therefore, we must ascertain what was the relative value of gold and silver when the par was fixed at 34s. $11\frac{1}{4}$g. Hamburg currency, and what is their relative value at the time we wish to calculate it.

"For example, if the price of standard gold was L.3, 17s. $10\frac{1}{2}$d. per oz., and silver 5s. 2d., an ounce of gold would then be worth 15·07 ounces of silver, and twenty of our standard shillings would then contain as much pure silver as 35s. 11 grotes and $\frac{1}{4}$ Hamburg currency. But if the ounce of gold were L.3, 17s. $10\frac{1}{2}$d., and silver 5s. (which it was on 2d January 1798), the ounce of gold would then be worth 15·57 ounces of silver. If L.1 sterling at par, therefore, be worth 15·07 ounces of silver, then at 15·57 it would be at three per cent. premium; and three per cent. premium on 34s. $11\frac{1}{4}$d. is 1 schilling 1 grote and $\frac{9}{10}$, so that the par, when gold is to silver as 15·57 to 1, will be 36 schillings 1 grote and $\frac{1}{10}$. The above calculation will be more easily made by stating, as 15·07 : 34–$12\frac{1}{4}$ :: 15·57 : 36–$1\frac{1}{10}$."[3]

As it is their intrinsic worth in bullion which determines the value of coins in exchange transactions, those of equal weight and purity are reckoned equivalent to each other, though some of them may have been coined at the expense of the state, and others charged with a duty or seignorage on their coinage. The latter may, if not issued in excess, pass current in the country in which they are coined for their value in bullion *plus* the duty; but they will not pass anywhere else, except at their bullion value.[4]

But the principal source of fluctuations in the nominal price of bills of exchange, is to be found in the varying value of the *paper* currency of commercial countries. The disorders which arose in remoter ages from diminishing the bullion contained in coins of the same denomination have since been reproduced in another form, and often to a still more ruinous extent, in the depreciation of paper currency.

Influence of depreciated paper currency on the exchange.

The impossibility of retaining a comparatively large quantity of coin or bullion, or of paper convertible into coin, in a particular country, limited the issues of the Bank of England previously to the Restriction Act of 1797; and it has equally limited them since the resumption of specie payments in 1821, and sustained the value of our currency on a level with gold. When the bank starves the circulation, or issues less paper than is necessary, bullion is imported, sent to the mint to be coined, and thrown upon the market. And when, on the other hand, the bank issues too much paper, and thereby depresses its value relatively to gold, it becomes profitable to demand payment of its notes, and to export the specie thus obtained either as coin or as bullion. In this way the vacuum is filled up when bank-notes are deficient, the excess removed when they are redundant, and the value of the currency preserved nearly equal.

But from 1797 down to 1821 this principle was suspended. During that period, the bank was relieved from the obligation to pay her notes in gold; while, owing to their being made legal tender, their circulation was insured. Hence, their value exclusively depended (see article MONEY) on the

[1] It is necessary to observe, that it is here supposed that the clipped or degraded money exists in such a degree of abundance as only to pass current at its bullion value. If the quantity of clipped money were *sufficiently limited*, it might, notwithstanding the diminution of weight, pass current at its mint value; and then the par would have to be estimated, not by its relative weight to foreign money, but by the mint price of bullion. This principle must be constantly kept in view.

[2] *Wealth of Nations*, p. 210.

[3] *An Inquiry into the effects produced on the National Currency by the Bank Restriction Bill*, &c., 2d edit., p. 94.

[4] Previously to 1817, no seignorage had for a very long period been deducted from either the gold or silver coins of Great Britain; but in the great recoinage of that year, the value of silver was raised from 5s. 2d. to 5s. 6d. an ounce, or nearly in the proportion of $6\frac{1}{2}$ per cent. The gold coins, however, are still coined free of expense, and no variation has been made in their standard. The proportion of silver to gold in the coins is now as $14\frac{287}{1000}$ to 1; but their proportion to each other, according to their mint valuation, is as $15\frac{209}{1000}$ to 1.

extent to which they were issued compared with the demand.

There is no difference, in its influence over the exchange, between a degraded metallic and a depreciated paper currency. And when a country with either the one or the other has any dealings with another whose currency is of its full value, the exchange is nominally against her to the extent of the degradation or depreciation. The nominal exchange between any two or more places, is, in fact, always adjusted according to the values of their currencies, being most favourable to that whose currency approaches nearest to its standard, and most unfavourable to that whose currency is most degraded or depreciated.

The intercourse between Great Britain and Ireland subsequently to the restriction on cash payments in 1797, furnishes some striking proofs of the effect which inordinate issues of paper have in depressing the exchange.

The nominal value of the Irish shilling being raised in 1689 from 12d. to 13d.,[1] L.108, 6s. 8d. Irish money became equal to only L.100 of British money, so that the exchange between Great Britain and Ireland was said to be at par when it was nominally $8\frac{1}{3}$ per cent. against the latter. In the *eight* years previous to 1797, when the paper currency of both countries was convertible into gold, the exchange between London and Dublin fluctuated from $7\frac{1}{2}$ to 9 per cent., that is, from $\frac{5}{6}$ per cent. in favour of Dublin to $\frac{2}{3}$ per cent. against it. In September 1797 it was at 6 per cent., or $2\frac{1}{3}$ per cent. in favour of Dublin. The amount of bank of Ireland notes in circulation in January 1797 was only L.621,917; whereas in April 1801 they had increased to L.2,286,471, and the exchange was then at 14 per cent., or $5\frac{2}{3}$ per cent. against Dublin. In 1803, the Bank of Ireland notes in circulation averaged L.2,707,956, and in October that year the exchange was quoted at 17 per cent., that is, $8\frac{2}{3}$ per cent. against Dublin!

The fact of the exchange between London and Dublin having fluctuated so little from par for the eight years previously to the restriction, shows that the circulating medium of Great Britain and Ireland had then been adjusted nearly according to the wants of the two countries. But, in these circumstances, it was evidently impracticable, supposing the value of British currency to remain nearly stationary, that the amount of Irish bank paper could be more than quadrupled in the short space of six years, without rendering the currency of Ireland redundant, and sinking its value below that of England. Had the Bank of England increased its notes in something like the same ratio as the Bank of Ireland, then, as the currency of both countries would have been equally depreciated, the exchange between London and Dublin would have continued at par. While, however, the notes of the Bank of Ireland were increased from L.621,917 to L.2,707,956, or in the proportion of 1 to 4·3, those of the Bank of England were only increased from L.9,181,843 (their number on 7th January 1797), to L.16,505,272, or in the proportion of 1 to 1·8. But for this addition to its issues by the Bank of England, the exchange, it is plain, would have been still more unfavourable to Dublin.

In the debates on the *Bullion Report*, it was contended that the increase of Bank of Ireland paper could not have been the cause of the unfavourable exchange upon Dublin, seeing that it had again become favourable after the issues of the Bank of Ireland had been still further increased. But to give this reasoning the least weight, it should have been shown that the currency of Great Britain retained its value in the interim, or that it had not been depreciated to the same extent as that of Ireland. For it is obvious that the depreciation of Irish bank paper might go on subsequently to 1804, and yet if English bank paper were depreciated still more rapidly, the exchange would become more in favour of Dublin. This is merely supposing the circumstances which took place in the first six years of the restriction to be reversed in the second six. Let us inquire how the fact stands.

We have seen that, in 1803, when the exchange was nominally 10 per cent. against Dublin, the issues of the Bank of England amounted to L.16,505,272, and those of the Bank of Ireland to L.2,707,956. And by referring to the accounts of the issues of the latter from 1797 to 1819, published by authority, it is seen that in 1805–1808 they were rather diminished; and that in 1810 they amounted to only L.3,251,750, being an increase of not more than L.543,794 in the space of seven years, or at the rate of $2\frac{6}{7}$ per cent. per annum; but in the same period (from 1803 to 1810) the issues of the Bank of England were increased from L.16,505,272 to L.22,541,523, or at the rate of 5 per cent. per annum. And this is not all. According to Mr Wakefield[2] there were *fifty* registered bankers in Ireland in 1804, and only *thirty-three* in 1810, of which fourteen were new houses, thirty-one of the old establishments having disappeared; and "I believe," says Mr Wakefield, "for the most part failed." This extraordinary diminution of the country paper of Ireland, for the reduction of the issues was at least proportional to the reduction in the number of banks, could not fail greatly to raise its value, and to countervail a corresponding increase in the issues of the national bank. Now, the reverse of all this took place in Britain. In 1800 there were 386 country banks in this country; and in 1810, this number, instead of being diminished as in Ireland, had increased to 721, having at least three times the number of notes in circulation in the latter as in the former period!

It appears, therefore, that when, in the period between 1797 and 1804, the amount of paper in circulation in Ireland was increased, and its value depressed, faster than in England, the exchange between London and Dublin became proportionally unfavourable to the latter; and, on the other hand, it appears, that when, in the six years subsequent to 1804, the paper currency of England was increased more rapidly than that of Ireland, its relative value was diminished, and the *nominal* exchange became more favourable to Dublin.

This is sufficiently conclusive. But there is still better evidence to show that the unfavourable exchange of Dublin upon London, in 1802, 1803, 1804, &c., was entirely owing to the comparative redundancy or depreciation of Irish bank paper. The linen manufacturers and weavers, with the majority of the other inhabitants of a few counties in Ulster, being, at the period of the restriction, strongly disaffected towards government, very generally refused to receive bank-notes in payment either of commodities or wages. The landlords having also stipulated for the payment of their rents in specie, a gold currency was maintained in the northern long after it had been banished from the southern parts of Ireland. If, therefore, the depression of the exchange between London and Dublin had been occasioned, as many contended, by an unfavourable balance of trade between Ireland and Great Britain, or by remittances from the former on account of absentees, it would have been equally depressed between London and the commercial towns in the northern counties. But so far was this from being the case, that in December 1803, when the exchange of Dublin on London was at $16\frac{1}{4}$ per cent., that of Belfast on London was at $5\frac{1}{4}$; or, in other words, at the very time that the exchange between Dublin, which had a paper currency, and London, was about 8 per cent. against Ireland,

[1] By a proclamation of James II. The arrangement was continued by the revolutionary government, and was confirmed by proclamation, 29th September 1737. But in 1825 the currencies of Great Britain and Ireland were assimilated.

[2] *Account of Ireland*, vol. ii., p. 171.

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the exchange between Belfast, which had a gold currency, and London, was about 3 per cent. in its favour. And this is not all: for, while there was a difference of 11 per cent. in the rate of exchange between Dublin and London, and Belfast and London, the inland exchange between Dublin and Belfast was about 10 per cent. in favour of the latter; that is, bills drawn in Dublin, and payable in the gold currency of Belfast, brought a premium of 10 per cent., while bills drawn in Belfast, and payable in the paper currency of Dublin, sold at 10 per cent. discount![1]

It is unnecessary to refer to the history of the French *assignats*, or of the paper currency of the continental powers generally, and of the United States, to corroborate what has been advanced. Such of our readers as wish for farther information upon these points may have recourse to the fourth volume of the "Cours d'Economie Politique" of M. Storch,[2] where they will find an instructive account of the influence of inordinate issues of paper on the price of bullion and the exchange, in almost every country of Europe. They are, in every case, similar to those now stated.

It only remains to determine the influence of fluctuations in the *nominal* exchange over exports and imports.

Influence of fluctuations of exchange over imports and exports.

When the exchange is at par, the operations of the merchant are regulated entirely by the difference between foreign prices and home prices. He imports such commodities as sell at home for so much more than they cost abroad as will indemnify him for freight, insurance, &c., and yield, besides, an adequate remuneration for his trouble, and for the capital employed in the business; and he exports those whose price abroad is sufficient to cover all expenses, and to afford a similar profit. But when the *nominal* exchange becomes unfavourable to a country, the premium which its merchants receive on foreign bills has been said to enable them to export with profit, in cases where the difference between the price of the exported commodities at home and abroad might not be such as to permit their exportation with the exchange at par. Thus, if the *nominal* exchange were 10 per cent. against this country, a merchant who had consigned goods to his agent abroad, would receive a premium of 10 per cent. on the sale of the bill; and if we suppose freight, insurance, mercantile profit, &c., to amount to 6 or 7 per cent., it would at first sight appear as if we might, in such circumstances, export commodities, although their price at home were 3 or 4 per cent. higher than in other countries. If, on the other hand, the *nominal* exchange were in our favour, or if bills *on* this country sold at a premium, it would appear as if foreigners would then be able to consign goods to our merchants, or the latter to order goods from abroad, when the difference of real prices would not of itself lead to an importation.

But a very little consideration will suffice to show that fluctuations in the *nominal* exchange have no such effects. That fall in the value of the currency which renders the exchange unfavourable, and causes foreign bills to sell at a premium, equally increases the price of commodities. And hence, however great, the premium which exporters gain by selling bills on their correspondents abroad, merely indemnifies them for the enhanced price of the goods exported. In such cases, mercantile operations are conducted precisely as they would be were the exchange really at par; that is, by a comparison of real prices at home and abroad, meaning by real prices, the prices at which commodities would be sold provided there were no depreciation of the currency. If these admit of exportation or importation with a profit, the circumstance of the nominal exchange being favourable or unfavourable will make no difference whatever on the transaction.

"Suppose," says Mr Blake, who has very successfully illustrated this part of the theory of exchange, "the currencies of Hamburg and London being in their due proportions, and therefore the *nominal* exchange at par, that sugar, which, from its abundance in London, sold at L.50 per hogshead, from its scarcity at Hamburg would sell at L.100. The merchant in this case would immediately export. Upon the sale of his sugar, he would draw a bill upon his correspondent abroad for L.100, which he could at once convert into cash by selling it in the bill market at home, deriving from this transaction a profit of L.50, under deduction of the expenses of freight, insurance, commission, &c. Now, suppose no alteration in the scarcity or abundance of sugar in London and Hamburg, and that the same transaction were to take place after the currency in England had been so much increased that the prices were doubled, and, consequently, the *nominal* exchange 100 per cent. in favour of Hamburg, the hogshead of sugar would then cost L.100, leaving apparently no profit whatever to the exporter. He would, however, as before, draw his bill on his correspondent for L.100; and, as foreign bills would bear a premium of 100 per cent., he would sell this bill in the English market for L.200, and thus derive a profit from the transaction of L.100 depreciated, or L.50, estimated in undepreciated currency,—deducting, as in the former instance, the expense of freight, insurance, commission, &c.

"The case would be precisely similar, *mutatis mutandis*, with the importing merchant. The unfavourable *nominal* exchange would appear to occasion a loss amounting to the premium on the foreign bill which he must give in order to pay his correspondent abroad. But if the difference of *real* prices in the home and foreign markets were such as to admit of a profit upon the importation of produce, the merchant would continue to import, notwithstanding the premium; for that would be repaid to him in the advanced *nominal* price at which the imported produce would be sold in the home market.

"Suppose, for instance, the currencies of Hamburg and London being in their due proportions, and therefore the *nominal* exchange at par, that linen which can be bought at Hamburg for L.50 will sell here at L.100. The importer immediately orders his correspondent abroad to send the linen, for the payment of which he purchases at L.50 a foreign bill in the English market; and, on the sale of the consignment for L.100, he will derive a profit amounting to the difference between L.50 and the expense attending the import.

"Now, suppose the same transaction to take place without any alteration in the scarcity or abundance of linen at Hamburg and London, but that the currency of England has been so augmented as to be depreciated to half its value, the *nominal* exchange will then be 100 per cent. against England, and the importer will not be able to purchase a L.50 foreign bill for less than L.100. But as the prices of commodities here will have risen in the same proportion as the money has been depreciated, he will sell linen to the English customer for L.200, and will, as before, derive a profit amounting to the difference between L.100 depreciated, or L.50 estimated in undepreciated money, and the expenses attending the import.

"The same instances might be put in the case of a favourable exchange; and it would be seen, in the same manner, that *nominal* prices and the *nominal* exchange being alike dependent on the depreciation of currency, whatever apparent advantage might be derived from the former would be counterbalanced by a loss on the latter, and *vice versa*."[2]

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[1] Farther information on this subject may be obtained from the Report, 1804, of the Committee of the House of Commons upon the state of the circulating paper in Ireland, its specie, &c.; from Sir Henry Parnell's pamphlet on the same subject; and from the pamphlets of Lord King, Huskisson, &c.

[2] Paris, 1823, 4 vols. 8vo.

Exchange.

It appears, therefore, that fluctuations in the *nominal* exchange have no effect on trade. A fall in the exchange obliges the country to which it is unfavourable to expend a greater *nominal* sum in discharging a foreign debt than would otherwise be necessary; but it does not oblige it to expend a greater real value. The depression of the *nominal* exchange can neither exceed nor fall short of the comparative depreciation of the currency. If British currency were depreciated 10 or 15 per cent., the *nominal* exchange would be 10 or 15 per cent. against us; and we should be compelled, in all transactions with foreigners, to give them 22s. or 23s. for what might otherwise have been procured for 20s. But as neither 22s. nor 23s. of such depreciated paper is more valuable than 20s. of paper undepreciated, payment of a foreign debt would, it is evident, be as easily made in the one currency as in the other; and mercantile transactions would, in such circumstances, be conducted exactly as they would have been had there been no depreciation, and the *nominal* exchange at par.

Sect. II.—*Real Exchange.*

Real exchange.

Having thus endeavoured to trace the influence which variations in the value of currencies have over the exchange, we proceed to consider how far it is influenced *by fluctuations in the supply and demand for bills.* To facilitate this inquiry, we shall exclude all consideration of changes in the value of money, and suppose the currencies of the different countries having an intercourse together to be equal in weight and purity to their mint standards, and that each has its proper supply of bullion.

When two nations trade together, and each purchases of the other commodities of the same value, their debts and credits are equal, and the real exchange is, of course, at par. But it rarely happens that the debts reciprocally due by any two countries are equal. There is almost always a balance owing on one side or other, which affects the exchange. If, for example, the debts due by London to Paris exceed those due by the former to the latter, the demand in London for bills on Paris will be greater than the demand in Paris for bills on London; and the *real* exchange will, consequently, be in favour of Paris and against London.

The expense of transferring bullion from one country to another limits the range within which the rise and fall of the real exchange between them is confined. In this respect, as in most others, transactions between foreign countries depend on the same principles which govern those between different parts of the same country. We have already seen that the fluctuations in the real exchange between London and Glasgow cannot exceed the expense of transmitting money between those cities. And this principle holds universally. Whatever may be the expense of transmitting bullion, which is the money of the commercial world, between London and Paris, London and Hamburg, New York, &c., the real exchange of the one on the other cannot, for any considerable period, be depressed to a greater extent. No merchant will pay a higher premium for a bill to discharge a debt abroad, than will suffice to cover the expense of transmitting bullion to his creditor.

Hence it appears that whatever obstructs or fetters the intercourse among different countries, proportionally widens the limits within which fluctuations in the *real* exchange may extend. And hence the reason why it varies so much more in war than in peace. The amount of the bills drawn on a country engaged in hostilities is liable, from various causes, to be suddenly increased; though, whatever may be the amounts thus thrown upon the market, the depression of the exchange cannot, for any length of time, exceed the expense of conveying bullion from the debtor to the creditor country. But during war this expense, which consists of freight, insurance, &c., is sometimes much augmented. The evidence annexed to the *Report of the Bullion Committee* shows that the cost of conveying gold from London to Hamburg, which, prior to the Revolutionary war, amounted to two or two and a half, had increased, in the latter part of 1809, to about seven per cent.; so that the limits within which fluctuations in the real exchange might range in 1809 were about three times as great as those within which they were confined in 1793.

Owing to our having the complete command of the sea, and our commerce not being subjected even to the depredations of privateers, the cost of freight and of the conveyance of bullion between this country and others has not been affected by the war in which we are now (1855) unluckily engaged.

The real exchange between neighbouring countries is generally, on the principle now explained, less likely to fluctuate than that between distant countries. It costs considerably less to transmit bullion from London to Dublin or Paris, than to New York or Canton. And, as fluctuations in the *real* exchange are limited by this cost, they may evidently extend proportionally farther between distant places than between such as are contiguous.

We have next to investigate the circumstances which give rise to a favourable or an unfavourable balance of payments, and to appreciate their effects on the real exchange, and on trade in general.

Balance of payments.

A very great, if not the principal, source of the errors into which merchants, and the majority of writers on exchange, have been betrayed in regard to the balance of payments, appears to have originated in their confounding the sum which imported commodities fetch in the home market, with their cost abroad. It is obviously, however, by the amount of the latter only, that the balance of payments, and consequently the *real* exchange, is influenced. A cargo of corn, for example, which cost L.3000 free on board at Odessa, may be worth L.4500 when imported into England; but the foreign merchant would not, unless he sent hither the corn, be entitled to draw on London for more than its original cost, or L.3000. It is clear, therefore, on the slightest consideration, that the fact of the imports being more valuable than the exports does not authorize the conclusion that the balance of payments is against us. A favourable or an unfavourable balance depends entirely on the sum due *to* foreigners for commodities bought from them being less or more than the sum due *by* them for commodities bought from us. It has nothing to do with the prices eventually obtained for the imported or exported commodities.

The *mercantile* system of commercial policy, which continues to preserve a powerful influence in most countries, had for its grand object the creation of a favourable balance of payments, by facilitating exportation and restricting importation. It is foreign to our purpose to make any inquiry in regard to the principles of this system, except in so far as they are connected with exchanges. But it may be easily shown, in opposition to the commonly received opinions, that under ordinary circumstances the value of the imports into commercial countries always exceeds the value of their exports; and that this excess or balance has not, speaking generally, any tendency to render the real exchange unfavourable.

It is the business of the merchant to carry the products of different countries from those places where their value is least, to those where it is greatest; or, which is the same thing, to distribute them according to the effective demand. There could, however, be no motive to export any article, unless that which was to be imported in its stead were more valuable. When an English merchant orders a quantity of Polish wheat, he supposes it will sell for so much more than

[1] *Observations*, &c., p. 48.

its price in Poland as will suffice to pay the cost of freight, insurance, &c., and to yield, besides, the ordinary rate of profit on the capital employed in the transfer. If the wheat did not sell for this much, its importation would be productive of loss. Merchants never export but in the view of importing articles of greater value. Instead of an excess of exports over imports being any criterion of an advantageous commerce, it is quite the reverse. And the truth is, notwithstanding all that has been said and written to the contrary, that unless the value of the imports exceeded that of the exports, foreign trade could not be carried on. Were this not the case—were the value of the exports always greater than that of the imports, there would be a loss on every transaction with foreigners, and the trade with them would either not be undertaken, or, if begun, would be speedily relinquished.

In England, the rates at which exports and imports are officially valued were fixed so far back as 1696. The very great alteration which has since taken place in the value of money, and in the cost of the greater number of the commodities of this and other countries, has rendered this official valuation, though valuable as a means of determining their quantity, of no use whatever as a criterion of the true value of the imports and exports. To obviate this defect, accounts of the *real* or *declared* value of the exports, prepared from the declarations of the merchants, are annually laid before parliament. There is, however, no such account of the imports; and it is, perhaps, impossible to frame one with anything like accuracy. It has also been alleged, and apparently with some foundation, that merchants have frequently exaggerated the value of articles entitled to drawbacks. But the extension and improvement of the warehousing system, and the decrease in the number of drawbacks, has very materially lessened whatever fraud or inaccuracy may have arisen from that source. The declared value of the exports may now be considered as pretty near the truth, at least sufficiently so for all practical purposes.

If perfectly accurate accounts could be obtained of the values of the exports and imports, there can be no manner of doubt that in all ordinary years the latter would considerably exceed the former. The value of an exported commodity is estimated when it is shipped, before its value is increased by the expense incurred in transporting it to the place of its destination; whereas the value of the commodity imported in its stead is estimated after it has arrived at its destination, and been enhanced by the charges on account of freight, insurance, importer's profits, &c.

It is of little importance, in so far at least as the interests of commerce are concerned, whether a nation carries its own imports and exports, or employs others. A carrying nation appears to derive a comparatively large profit from its commercial transactions. But this excess of profit is seldom more than a fair remuneration for the capital it employs, and the risk it incurs, in transporting commodities. Were the trade between this country and France wholly carried on in British bottoms, our merchants, in addition to the value of the exports, would also receive the cost of their carriage to France. This, however, would be no loss to the French. They must pay the freight of the commodities they import. And if English ships sail on cheaper terms than those of their own country, there is no good commercial reason, though there may be others of a different kind, why they should not employ them in preference.

In the United States the value of the imports, deduced from the custom-house returns, almost always exceeds the value of the exports.[1] And though we have been accustomed to consider the excess of exports over imports as the only sure criterion of an advantageous commerce, the practical politicians of America early discovered "that the real gain of the United States has been nearly in proportion as their imports have exceeded their exports."[2] The great excess of imports into the Union is in part occasioned by the Americans generally exporting their own surplus produce, and receiving from foreigners not only an equivalent for the exports, but also for the cost of their conveyance to their markets. "In 1811," says the author just quoted, "flour sold in America for 9 dol. 50 cents per barrel, and in Spain for 15 dol. The value of the cargo of a vessel carrying 5000 barrels of flour would, therefore, be estimated, at the period of its exportation, at 47,500 dol.; but as this flour would, because of freight, insurance, exporter's profits, &c., sell in Spain for 75,000 dol., the American merchant would be entitled to draw on his agent in Spain for 27,500 dol. more than the flour cost in America, or than the sum for which he could have drawn had the flour been exported on account of a Spanish merchant. But the transaction would not end here: the 75,000 dol. would be vested in some species of Spanish or other European goods fit for the American market; and the freight, insurance, &c., on account of the return cargo would perhaps increase its value to 100,000 dol.; so that, in all, the American merchant might have imported commodities worth 52,500 dol. more than the flour originally sent to Spain." It is as impossible to doubt that this transaction is advantageous, as it is to doubt that its advantage consists in the value of the imports exceeding that of the exports. And it is clear that America might have the balance of payments in her favour, though such transactions as the above were multiplied to any conceivable extent.

Instead, therefore, of endeavouring to limit the trade with countries from which the imports exceed the exports, we should give it every possible facility. Every man considers that market as the best in which he obtains the highest price for his goods. Why then exclude him from it? Why compel a merchant to sell a cargo of muslin, iron, &c., for L.10,500, rather than L.11,000 or L.12,000? The wealth of a state is made up of the wealth of individuals. And what more effectual method of increasing individual wealth can be devised than to permit buying in the cheapest and selling in the dearest markets?

It would be difficult to estimate the mischief which absurd notions relative to the balance of trade have occasioned in most commercial countries. They have been particularly injurious to Great Britain. The restrictions imposed on the trade with France originated in the prevalence of prejudices to which they gave rise. The great, or rather the only, argument insisted on by those who prevailed on the legislature to declare the French trade a *nuisance*,[3] was founded on the alleged fact, that the value of the imports from France considerably exceeded the value of the exports to her. The balance was termed a tribute paid by England; and it was sagaciously asked, what had we done that we should be obliged to pay so much money to our natural enemy? Those considerate and patriotic persons seem to have supposed that our merchants brought commodities from France for no better reason than that they were French, or to oblige that ingenious people. But they were not quite so disinterested. They imported French wines, silks, and so forth, for the same reasons that they imported the sugar of the West Indies, the teas and spices of the East, and the timber of the Baltic, that is, because there was a demand for them, and because they were worth more in our markets than the native products exported in their stead. The reason assigned for prohibiting the trade affords a conclusive proof of its having been advantageous. There cannot, indeed, be a doubt, that an unlimited freedom of

1 Such was always the case till the late extraordinary export of gold from California.

2 Pitkin on the *Commerce of the United States*, 2d ed., p. 280.

3 Prohibition Act, 1st William and Mary.

intercourse between the two countries would be of great service to both. Supposing it to be so arranged, does any one imagine that we should export or import any commodity to or from France, provided we could either sell or buy it on better terms anywhere else? If restrictions on the trade with any particular country be not injurious, that is, if it be either a losing or a less advantageous trade than that with other countries, we may be assured that the throwing it completely open would not make a single individual engage in it.

Everybody knows that these conclusions are not only theoretically true, but have been practically verified. The abolition of the discriminating duty on French wines, the reduction of the exorbitant duty on brandy, the repeal of the prohibition against importing silks, and the opening of our ports to French corn and flour, have all been advantageous. And though it be true that the prejudices of the French, and the high duties which they continue to impose on most articles of British produce, confine the trade within comparatively narrow limits, they have not made it unprofitable, and are more injurious to themselves than to us. It is a curious fact, that notwithstanding the great amount of our imports from France, and our expenditure in that country on account of absentees, the state of the exchange shows that the balance of payments is usually in our favour.

But the partisans of the exclusive or mercantile system may perhaps say, that they do not mean to contend that it is profitable to export more than is imported; but that, by exporting an excess of raw and manufactured produce, the balance of payments is rendered favourable, and that this balance (which they regard as representing the entire nett profit made by the country on its transactions with foreigners) is always paid in bullion.

It may, however, be easily shown that this statement is altogether erroneous; that a balance, whether on the one side or the other, is seldom or never cancelled by means of bullion; and that it is not a measure, and has, indeed, nothing to do with the profit or loss attending foreign commercial transactions.

If the premium on foreign bills, in a country with an unfavourable real exchange, be less than the cost of sending bullion abroad, it would be contradictory to suppose that it should be exported. And though the premium on such bills were to increase, till it become equal to, for it cannot exceed, the cost of exporting the precious metals, it does not follow that they will then be exported. That would depend on whether bullion were, at the time, the cheapest exportable commodity; or, in other words, whether a remittance of bullion was the most advantageous way in which a debt might be discharged. If a London merchant owe L.1000, or other sum, in Paris, he endeavours to find out the cheapest method of paying it. On the supposition that the *real* exchange is 2 per cent. below par, and that the expense of remitting bullion is also 2 per cent., it will be indifferent to him whether he pay L.20 of premium for a bill of L.1000, payable in Paris, or incur an expense of L.20 in remitting L.1000 worth of bullion direct to that city. If the prices of cloth in Paris and London be such, that it would require L.1030 to purchase and send as much cloth to Paris as would sell for L.1000, he would no doubt prefer buying a bill or exporting bullion. But if, by incurring an expense of L.1010, the debtor may send as much hardware or cotton to Paris as would sell for L.1000, he would as certainly prefer paying his debt by exporting the one or the other. It would save him 1 per cent. more than if he bought a foreign bill or remitted bullion, and 2 per cent. more than if he exported cloth. Had there been any other commodity which might have been exported with more advantage, he would have used it in preference.

It is obvious, therefore, that the trade in bullion is governed by the same principles which govern the trade in other things. It is exported when its exportation is advantageous; that is, when it is less valuable at home, and more valuable abroad, than anything else; and it will not otherwise be exported. The balance of payments might be twenty or thirty millions against a country, without depriving it of a single ounce of bullion. No merchant would remit L.1000 worth of gold or silver from England to discharge a debt in Paris, if he could invest L.970, L.980, L.990, or any sum under L.1000, in any other species of merchandise which, exclusive of expenses, would sell in France for that amount. Those who deal in the precious metals are as much alive to their interests, as those who deal in coffee, or sugar, or indigo. But who would attempt to discharge a foreign debt by exporting coffee which cost L.100, if he could effect the same object by exporting indigo which cost only L.95? No bullion will ever be exported unless its value be less in the exporting country than in that to which it is sent; and unless it be, at the same time, the most advantageous article of export.

2. It is in vain to contend that an unrestricted freedom of trade might render some unfortunate country indebted to another so happily situated that it had no demand for any sort of ordinary merchandise, and would only accept of cash or bullion in exchange for its exports. A case of this sort never did, and never will, occur. It is not even possible. A nation which is in want of money must be in want of other things; for men desire money only because it is the readiest means of increasing their command over necessaries and enjoyments. The extreme variety, too, in the soils and climates—in the machinery, skill, and industry of the people of different countries—occasion extraordinary differences in their products and prices. Some articles of the highest utility are peculiar to certain districts. And there will ever be a demand, not only for such articles, but also for those which, though they may be produced at home, may be imported of a better quality, or at a lower price. Nor, till the passion of accumulation be banished from the human breast, will there cease to be a desire to send commodities from places where their exchangeable value is least, to those where it is greatest.

3. In treating of the *nominal* exchange, we endeavoured to show that no single country can continue, for any length of time, to import or export a greater amount of bullion than may be necessary to preserve the precious metals in it in their proper relation to those of other countries; or, which is the same thing, to have the *real* exchange either permanently favourable or unfavourable. But though this principle be strictly true in reference to its aggregate exchanges, it may be incorrect if its exchange with one country only be considered. Great Britain, for example, may generally have the exchange in her favour with America, provided she have it generally, and to a nearly equal extent, against her with the East Indies, or some other country. "She may," to use the words of Mr Ricardo, "be importing from the north the bullion which she is exporting to the south. She may be collecting it from countries where it is relatively abundant, for others where it is relatively scarce, or where, from some particular causes, it is in great demand. Spain, who is the great importer of bullion from America, can never have an unfavourable exchange with her colonies; and as she must distribute the bullion she receives among the different nations of the world, she can seldom have a favourable exchange with the countries with which she trades."[1]

On this principle, Lord King successfully accounted for the favourable exchange between this country and Hamburg from 1770 to 1799. He showed that the importation of bullion from Hamburg and other parts was not more than

[1] See *Reply to Mr Bosanquet's Observations on the Report of the Bullion Committee*, p. 17.

Exchange.

equivalent to the exports to the East Indies and the home consumption; that the demand corresponded to the supply; and that its value remained pretty stationary. The extraordinary influx of bullion into this country from the Continent at the era of the Bank restriction in 1797, and the favourable state of the exchange, were undoubtedly owing to the reduction in the issues of bank paper, and to the diminution of the gold currency caused by the hoarding of guineas. In 1797 and 1798, above *five* millions of guineas were coined at the mint; and this extraordinary demand for gold is of itself abundantly sufficient to account for the very favourable exchange of that period, and for the length of time during which it continued. But, at the same time that the demand for gold bullion for the mint was thus increased, the demand for silver bullion, for export to India, was proportionally augmented.

In 1795, the quantity exported by the East India Company and private parties amounted to......	151,795	ounces.
In 1796, to...	290,777	...
1797	962,880	...
1798	3,565,691	...
1799	7,287,327	...

From this period the exportation rapidly declined; and, in the years in which the exchange was most unfavourable, little or no silver was sent to India.

Instead, therefore, of the extraordinary importation of bullion from Hamburg in 1797 and 1798 affording, as Mr Bosanquet and others supposed, a practical proof of the fallacy of the opinion of those who contend that it is impossible, for any length of time, to subvert the natural equality in the value of bullion in different countries, it is a striking example of its truth. Without this influx, bullion in this country could not have maintained its proper comparative value. We imported it, because the reduction of the paper currency, and the increased exports of the East India Company, rendered its value higher here than on the Continent; and made it advantageous for the continental merchants to send it to us, in the same manner as they would have sent corn, or anything else for which we had an unusual demand. For, however favourable the *real* exchange between Hamburg and London might have been to the latter, we should not have imported an ounce of bullion, had it not been, at the time, the article with which Hamburg could most advantageously discharge her debt to London.

4. In the absence of other arguments, it would be sufficient to state, that it is physically impossible that the excess of exports over imports, as indicated by the custom-house returns, should be paid in bullion. Every country, with the exception of the United States, has its apparently favourable balance; and, of course, if they really existed, they would have to be paid by an influx of bullion from the mines correspondent to their aggregate amount. It is certain, however, that, previously to the late discoveries in California and Australia, the entire produce of the mines, though it had been increased in a *tenfold* proportion, would have been insufficient for this purpose! This fact is decisive of the degree of credit which ought to be attached to the commonly received opinions on this subject.

5. In the last place, the profit on transactions with foreigners does not consist in the quantity of bullion imported from abroad, but in "the excess of the value of the imports over the value of the exports." If, in return for exported commodities worth ten or twenty millions, we import such as are worth fifteen or thirty, we shall gain 50 per cent. by the transaction, though the exports should consist entirely of bullion, and the imports of corn, sugar, coffee, &c. It is a ridiculous prejudice that would make bullion be imported rather than any other article. But whatever the partisans of the exclusive system may say about its being a preferable product, a *marchandise par excellence*, we may be assured that it will seldom appear in the list of exports or imports, while there is any other thing with which to carry on trade that will yield a larger profit.

Exchange.

Thus it appears that the excess of exports over imports, instead of being any proof of an advantageous commerce, is distinctly and completely the reverse; that the value of the imports into commercial countries may, and almost always does, exceed the value of their exports, without rendering them indebted to foreigners; and that when a balance of debt has been contracted, that is, when the sum *payable to* foreigners for imports is greater than the sum *receivable from* them for exports, bullion will not be sent from the debtor to the creditor country, unless it be at the time the most profitable article of export.

We have in the previous *section* shown that fluctuations in the nominal exchange have no influence over foreign trade. When the currency is depreciated, the premium which an exporter derives from the sale of bills on his correspondent abroad, is barely equivalent to the increase in the price of the exports, occasioned by the depreciation. But when the premium on foreign bills is not caused by a fall in the value of money, but by a deficient supply of bills, there is no rise of prices, and then the unfavourable exchange undoubtedly operates as a stimulus to exportation. As soon as the *real* exchange diverges from par, the mere inspection of price currents is no longer enough to guide the operations of the merchant. If it be unfavourable, the premium which the exporters receive on the sale of bills must be included in the estimate of the profit they are likely to derive from the transaction. The greater that premium, the less will be the difference of prices necessary to make them export. An unfavourable *real* exchange has, in truth, exactly the same effect on exportation as a bounty equal to the premium on foreign bills.

Influence of fluctuations of real exchange over imports and exports.

But for the same reason that an unfavourable *real* exchange increases exportation, it diminishes importation. When it is unfavourable, the prices of foreign products brought to our markets must be so much under their prices here, as not merely to afford, exclusive of expenses, the ordinary profit on their sale, but also to pay the premium which the importer must give for a foreign bill, if he remit one to his correspondent, or for the discount, added to the invoice price, if the latter draw upon him. A less quantity of foreign goods will therefore suit our markets when the exchange is really unfavourable; and fewer payments having to be made abroad, the competition for foreign bills is diminished, and the exchange rendered proportionally favourable. A favourable *real* exchange, consequently, operates as a duty on exportation and a bounty on importation.

Hence it is obvious that fluctuations in the *real* exchange have a necessary tendency to correct themselves. They can never, for any considerable period, exceed the expense of transmitting bullion from the debtor to the creditor country. And the exchange cannot continue permanently favourable or unfavourable even to this extent. When favourable, it corrects itself by restricting exportation and facilitating importation; and when unfavourable, it produces the same effect by stimulating exportation and obstructing importation. The true PAR forms the centre of these oscillations. And though the thousand circumstances which daily and hourly affect the state of debt and credit, prevent the ordinary course of exchange from being almost ever precisely at par, its fluctuations, whether on the one side or the other, are confined within certain limits, and have a constant tendency to disappear.

The natural tendency which the exchange has to correct itself is powerfully assisted by the operations of the bill merchants.

England, for example, may owe an excess of debt to Amsterdam, yet, as the aggregate amount of the debts due

by a commercial country, is generally balanced by the amount of those which it has to receive, the deficiency of bills on Amsterdam in London will most probably be countervailed by their redundancy in some other quarter. And, it is the business of the merchants who deal in bills, as of those who deal in bullion or any thing else, to buy them where they are cheap, that they may sell them where they are dear. They, therefore, buy up the bills drawn by other countries on Amsterdam, and dispose of them in London; and, by so doing, prevent any great fall in the price of bills on the former in the countries in which their supply exceeds the demand, and any great rise in Great Britain and the countries in which their supply happens to be deficient. In our trade with Italy, the bills drawn on England generally amount to a greater sum than those drawn on Italy. The bill merchants, however, by buying up the excess of Italian bills on London, and selling them in France, Holland, and other countries indebted to England, prevent the *real* exchange from being much depressed.

An unusual deficiency in the supply of corn, or of any article of prime necessity, by causing a sudden augmentation of imports, materially affects foreign debts and credits, and depresses the exchange. In time of war, the balance of payments is liable to be still further disturbed; the amount of the bills drawn on a country carrying on foreign hostilities, being increased by the whole expense of its armaments abroad, and of subsidies to foreign powers. But neither the conjoined nor separate influence of both or either of these causes has any permanent influence over the exchange. A sudden increase in the accustomed supply of bills must, in the first instance, by glutting the market, occasion their selling at a discount; but this effect will only be temporary. The unusual facilities which are then afforded for exportation, and the difficulties which are thrown in the way of importation, never fail speedily to bring the *real* exchange to par.

During a period of peace we may, in the too great ardour of speculative enterprise, export an excess of produce, overload the foreign market, and occasion such a decline in the prices of our goods abroad, as to make the imports less valuable than the exports with which they have been purchased. But such a state of things can only be of limited duration. The distress of which it is productive, assisted by the fall of the exchange, occasions a diminution of exports. The supply of our commodities in the foreign markets is rendered more nearly commensurate with the demand; till in no long time the value of the imports again exceeds, as it always ought to do, the value of the exports. But when a country has a large foreign expenditure to sustain, its exports are proportionally augmented. Whatever may have been the foreign expenditure of Great Britain during the late war, it is evident it could not be defrayed otherwise than by our annually exporting an equal amount of the produce of our land, capital, and labour, for which payment was not received, as in ordinary cases, by a corresponding importation of foreign commodities, but from the treasury at home. This is strictly true, even though the expenditure should have happened to be, in the first instance, discharged by remittances of bullion; for the increased supply of bullion which was thus required could be obtained only by an equally increased exportation of other products to the countries possessed of mines, or from which it was imported. Foreign expenditure, by increasing exports in proportion to its own amount, has no permanent influence over the exchange.

Thus it appears that an excess of exports, instead of being any criterion of increasing wealth at home, is only a certain indication of commercial losses, or of expenditure abroad. "When," says Mr Wheatley, "the exports exceed the imports, as they must do when there is a large foreign expenditure, the equivalents for the excess are received abroad in as full and ample a manner as if the produce which they purchased were actually imported and entered in the custom-house books, and afterwards sent to the seat of war for consumption. But from the circumstance of its not being inserted in the custom-house entries as value received against the produce exported for its payment, the latter is deemed to constitute a favourable balance, when it is in reality exported to liquidate a balance against us."[1]

But how conclusive soever this reasoning may appear, it has been said to be at variance with the fact; and the rise of the exchange at the end of the late war, during the suspension of cash-payments, has been appealed to as showing that its previous low rate had not been occasioned by any depreciation of the paper currency, but by the excessive amount of the bills drawn upon this country to defray war expenditure. The question, however, is not whether the exchange recovered from its depression during the suspension of cash-payments, for the influence of that measure depended entirely on the use made of it, but whether its recovery took place without the amount of bank paper of all sorts, or of the currency, being diminished? The statements made in the article MONEY are decisive upon this point. They show that the currency was very greatly diminished in 1814, 1815, and 1816; and that this diminution occasioned the rise in its value, and in the nominal exchange.

Mr Francis Horner, the well-informed chairman of the Committee on the High Price of Bullion, made the following statement in regard to this very question in his place in the House of Commons:—

"From inquiries he had made, and from the accounts on the table, he was convinced that a greater and more sudden reduction of the circulating medium had never taken place in any country than had taken place since the peace in this country, with the exception of those reductions that had taken place in France after the Mississippi scheme, and after the destruction of the assignats. The reduction of the currency had originated in the previous fall of the prices of agricultural produce. That fall had produced a destruction of country-bank paper, to an extent which would not have been thought possible, without more ruin than had actually ensued. The Bank of England had also restricted its issues. As appeared by the accounts recently presented, the average amount of its currency was not, during the last year, more than between L.25,000,000 and L.26,000,000; while two years ago it had been nearer L.29,000,000, and at one time even amounted to L.31,000,000. But, without looking to the diminution of Bank of England paper, the reduction of the country paper was enough to account for the rise which had taken place in the exchange."

Hence it appears that the rise of the exchange in 1815 and 1816, had nothing, or but little,[2] to do with the cessation of hostilities, and was entirely, or mainly, a consequence of the increased value of the currency, caused by the reduction of its quantity. Instead of being at variance with the principles we have been endeavouring to elucidate, this fact affords a strong confirmation of their correctness. And having been sanctioned by the fullest experience, they may be considered as beyond the reach of cavil and dispute.

An objection of a different sort has been made, to another part of the theory maintained in this *section*, which it may be proper to notice.

When the exchange becomes unfavourable, the premium, procured by the sale of the bill drawn on a foreign merchant to whom bullion has been consigned, is no greater than would be obtained by consigning to him an equivalent

[1] Wheatley, *on the Theory of Money*, p. 219.

[2] The real exchange might probably be affected to the extent of one or two per cent.

Exchange. amount of coffee, tea, sugar, indigo, &c. An unfavourable *real* exchange permits a merchant to export commodities which could not be exported were it at par, or favourable. But the advantage still remains of exporting those commodities in preference, whose price in the country from which they are sent, compared with their price in that to which they are sent, is lowest. Suppose, for example, that the expense of transmitting bullion from this country to France is *three* per cent., that the *real* exchange is *four* per cent. against us, that the price of bullion is the same in both countries, and that coffee, exclusive of the expenses of carriage, is really worth *four* per cent. more in France than in England. In such a case, it is obvious that the exporters of bullion would realise a profit of only *one* per cent., while the exporters of coffee would realise, inclusive of the premium on the sale of the foreign bill, a profit of *seven* per cent. And hence the opinion maintained by Colonel Torrens,[1] that when the exchange becomes unfavourable, those commodities which contain the greatest value in the smallest bulk, or on which the expense of carriage is least, are exported in preference, appears to have no good foundation. The prices of the commodities which nations trading together are in the habit of exporting and importing, are regulated not merely by the cost of their production, but also by the expense of their carriage from where they are produced to where they are consumed. If Great Britain were in the habit of supplying France with cottons and bullion, the average price of cottons in France, because of the expense required to convey them there, would probably be from 5 to 6 per cent. higher than in Britain; while, because of the comparative facility with which bullion may be transported from the one to the other, its value in Paris would not, perhaps, exceed its value here more than 1 per cent. Now, suppose that, when the prices of cottons and bullion in England and France are adjusted according to their natural proportions, the *real* exchange becomes unfavourable to us, it is clear that its fall gives no greater advantage to the exporters of bullion than to those of cottons. The rise in the price of foreign bills does not increase the expense of exporting the one or the other. It leaves the cost of their reduction and transportation exactly where it found it. During the depression of the exchange, the exporters of both articles get the premium on the bills drawn on their correspondents. But there is no inducement to export bullion in preference to cottons, unless the price of bullion increase more rapidly in France, or decline more rapidly in Great Britain, than that of cottons.

Whatever, therefore, may be the depression of the exchange, the merchant selects those commodities for exportation which, exclusive of the premium, yield the greatest profit on their sale. If bullion be one of these, it will of course be exported; if not, not. But of all commodities, bullion is that of which the value approaches nearest to an equality in different countries, so that it is the least likely to be exported during an unfavourable exchange. The demand for it is comparatively steady, and no great surplus quantity could be imported into one country without reducing, or exported from another without raising, its value, so as to unfit it either for exportation or importation. In most cases a small part only of an unfavourable balance is paid in bullion. The operations of the bullion merchants are chiefly confined to the distribution of the fresh supplies obtained from the mines, in proportion to the wants of different countries.

Sect. III.—*Computed Exchange.*

Having thus endeavoured to point out the manner in which variations in the values of the currencies of nations trading together, and in the supply and demand for bills, separately affect the exchange, it now only remains to ascertain their combined effect, or the *computed* or actual course of exchange.

Computed exchange. From what has been already stated, it is obvious, that when the nominal and real exchange are both favourable or both unfavourable, the *computed* exchange will express their *sum;* and that when the one is favourable and the other unfavourable, it will express their *difference.*

When, for example, the currency of Great Britain is of the mint standard and purity, while that of France is 5 per cent. degraded, the *nominal* exchange will be 5 per cent. in our favour. But the *real* exchange may, at the same time, be either favourable or unfavourable. If it be, also, favourable to the extent of one, two, three, &c., per cent., the computed exchange will be six, seven, eight, &c., per cent. in our favour. And, on the other hand, if it be unfavourable to the extent of one, two, three, &c., per cent., the *computed* exchange will be only four, three, two, &c., per cent. in our favour. When the *real* exchange is in favour of one country, and the *nominal* exchange equally against it, the *computed* exchange is at par, and *vice versa.*

A comparison of the market with the mint price of bullion affords the best and readiest means by which to ascertain the state of the exchange. When there are no restrictions on the trade in the precious metals, the excess of the market over the mint price of bullion affords an accurate measure of the depreciation of the currency. If the market and mint price of bullion at Paris and London exactly corresponded, then, inasmuch as the real value of bullion must be very nearly the same in both countries, the *nominal* exchange would be at par; and whatever fluctuations the computed exchange might exhibit, must, in such case, be traced to fluctuations in the *real* exchange, or in the supply and demand for bills. If, when the market price of bullion in Paris is equal to its mint price, it exceeds it 2 per cent. in London, it is a proof that our currency is 2 per cent. depreciated, and consequently the *nominal* exchange between Paris and London *must* be 2 per cent. against the latter. Instead, however, of the *computed* or actual course of exchange being 2 per cent. against London, it may be against it to a greater or less extent, or in its favour. It will be more against it provided the *real* exchange be also unfavourable; it will be less against it provided the *real* exchange be in favour of London, though to a less extent than the adverse *nominal* exchange; and it will be in favour of London, should the favourable *real* exceed the unfavourable *nominal* exchange. Thus, if, while British currency is 5 per cent. depreciated, and French currency at par, the computed or actual course of exchange between Paris and London were 10 or 12 per cent. against the latter, it would show that the *real* exchange was also against this country to the extent of 5 or 7 per cent. And if, on the other hand, the computed exchange were only 2 or 3 per cent. against London, it would show that the *real* exchange was 3 or 4 per cent. in its favour, and so on.

It has been already shown, that, in so far at least as the question of exchange is involved, the differences in the value of bullion in different countries are limited by the expense of its transit from one to another. And hence, by ascertaining whether a particular country exports or imports bullion to or from other countries, we may determine its comparative value in these countries. Suppose, for example, that the expense of conveying bullion from this country to France, including the profits of the bullion dealer, is 1 per cent.; it is clear, inasmuch as bullion is exported only to find its level, that whenever our merchants begin to export it to France, its value there must be at least 1 per cent. greater than in England; and, on the contrary, when they

[1] *Comparative Estimate,* &c.

import bullion from France, its value here must be, at least, 1 per cent. greater than in France. In judging of the exchange between any two countries, this circumstance should always be attended to. If no bullion be passing from the one to the other, we may conclude that its value is nearly the same in both; or, at all events, that the difference of its value is not more than the expense of transit. On the supposition that the entire expense, including profit, of conveying bullion from San Francisco to London is 5 per cent., and that London is importing bullion, it is clear, provided the real exchange be at par, and the currency of both cities at their mint standards, that the *nominal*, or, which in this case is the same thing, the *computed* exchange, will be 5 per cent. in favour of London. But if the currency of London be 5 per cent. depreciated, or, in other words, if the market price of bullion at London be 5 per cent. above its mint price, the *computed* exchange between it and San Francisco, supposing the *real* exchange to continue at par, will obviously be at par. It may therefore be laid down as a general rule, that when bullion begins to pass from one country to another, the expense of transit, provided the mint and market price of bullion in the exporting country correspond, will indicate how much the value of bullion in it is below its value in the country into which it is imported, and will be identical with its unfavourable *nominal* exchange; and that, when the market exceeds the mint price of bullion in the exporting country, the expense of transit added to this excess will give the total comparative reduction of the value of the precious metals in that country. The converse of this takes place in the country importing bullion. When its currency is of the mint standard, the expense of transit is the measure of its favourable nominal exchange; but when its currency is relatively redundant or degraded, the difference between the expense of transit and the excess of the market above the mint price of bullion, will measure the extent of the favourable or unfavourable nominal exchange. It will be favourable when the depreciation is less than the expense of transit, and unfavourable when it is greater.

From 1809 to 1815 inclusive, Great Britain continued to export gold and silver to the Continent. During this period, therefore, we must add the expense of its export to the excess of the market over the mint price of bullion, to get at the true relative value of British currency, and the state of the *real* exchange. Mr Goldsmid stated to the bullion committee that, during the last five or six months of 1809, the expense of transporting gold to Holland and Hamburg, including freight, insurance, exporter's profits, &c., varied from 4 to 7 per cent. But at the time that the relative value of bullion in Britain was at 5½ (medium of 4 and 7) per cent. below its value in Hamburg, the market price of gold bullion exceeded its mint price 16 or 20 per cent., or 18 per cent. at an average; so that the currency of this country, as compared with that of Hamburg, which differed very little from its mint standard, was depreciated to the extent of about 23½ per cent. Now, as the *computed* or actual course of exchange varied, during the same period, from 19 to 21 per cent. against London, it is plain that the *real* exchange could not be far from par. Had the *computed* exchange been less unfavourable, it would have shown that the *real* exchange was in favour of London; had it been more unfavourable, it would, on the contrary, have shown that the *real* exchange was against London.

Provided an accurate account could be obtained of the expense attending the transit of bullion from this country to the Continent during the subsequent years of the war, it would, most likely, be found, notwithstanding the extraordinary depression of the *nominal*, that the *real* exchange varied but little from par; and that the exportation of gold and silver was not a consequence of the balance of payments being against us, but of its being advantageous to export bullion, because of its being more valuable on the Continent. None will contend that, in 1809, 1810, &c., gold and silver were so redundant in this country as to sink their relative value. Any such supposition is out of the question. During the period referred to, they were sent abroad, because the depreciation of paper exceeded the cost of the transit of bullion; and it was everybody's interest to pay their debts in the depreciated currency, and to export that which was undepreciated to countries where it passed at its full value as coin, or in which bullion was in greater demand. Had our paper currency been sufficiently reduced, the supply of gold in the kingdom in 1809, 1810, &c., compared with the demand which must, under such circumstances, have been experienced, was so very small, that instead of exporting, we should have imported the precious metals from all parts of the world.

The extraordinary exportation of British goods to the Continent during the latter years of the war, has been very generally supposed to have been in great measure owing to the depression of the exchange. But, in so far as this depression was occasioned by the redundancy or depreciation of the currency, it could have no such effect. It is impossible, indeed, to form any opinion as to the influence of fluctuations in the *computed* exchange on export and import trade, without previously ascertaining whether they are a consequence of fluctuations in the *real* or *nominal* exchange. It is only by an unfavourable *real* exchange that exportation is facilitated; and it may be favourable when the *computed* exchange is unfavourable. "Suppose," to use an example given by Mr Blake, "the computed exchange between Hamburg and London to be 1 per cent. against this country, and that this arises from a *real* exchange which is favourable to the amount of 4 per cent., and a nominal exchange unfavourable to the extent of 5 per cent.; let the real price of bullion at Hamburg and London be precisely the same, and, consequently, the *nominal* prices different by the amount of the *nominal* exchange, or 5 per cent.; now, if the expenses of freight, insurance, &c., on the transit of bullion from Hamburg are 3 per cent., it is evident that a profit would be derived from the import of that article, notwithstanding the *computed* exchange was 1 per cent. against us. In this case the merchant must give a premium of 1 per cent. for the foreign bill, to pay for the bullion: L.100 worth of bullion at Hamburg would therefore cost him L.101, and the charges of importation would increase the sum to L.104. Upon the subsequent sale, then, for L.105 of depreciated currency in the home market, he would derive from the transaction a profit of L.1. This sum is precisely the difference between the *real* exchange and the expenses of transit, that part of the *computed* exchange which depends on the *nominal* producing no effect; since whatever is lost by its unfavourable state is counterbalanced by a corresponding inequality of *nominal* prices."[1] In the same manner it may be shown that, though the *computed* be favourable, the *real* exchange may be unfavourable; and that, consequently, it may be really advantageous to export, when it is apparently advantageous to import. But it would be tedious to multiply instances, which, as the intelligent reader will readily conceive, may be infinitely varied, and which have been sufficiently explained in the foregoing sections.

The real cause of the extraordinary importation of British produce into the Continent, in 1809, 1810, 1811, &c., notwithstanding the anti-commercial system of Napoleon, is to be found in the annihilation of the neutral trade, and our monopoly of the commerce of the world. The entire produce of the East and West was at our disposal. The Continental nations could neither procure colonial products, nor

[1] *Observations*, &c., p. 91.

Exchange.

raw cotton for the purposes of manufacturing, except from England. British merchandise was thus almost indispensable; and to this our immense exportation, in spite of all prohibitions to the contrary, is to be ascribed.

HISTORY AND INFLUENCE OF BILLS OF EXCHANGE.

History of bills of exchange.

It is not easy to discover the æra when bills of exchange were first employed to transfer and adjust the mutual claims and obligations of merchants. Their invention has been ascribed to the Arabians and Jews of the middle ages. But it seems certain that they were in use in remote antiquity. Isocrates states that a stranger who brought some cargoes of corn to Athens, furnished a merchant of the name of Stratocles with an order or bill of exchange on a town on the Euxine, where money was owing to him; and, because the person who had drawn the bill had no fixed domicile, Stratocles was to have recourse on a merchant in Athens, in the event of its being protested. The merchant, says Isocrates, who procured this order found it extremely advantageous, inasmuch as it enabled him to avoid risking his fortune on seas covered with pirates, and the hostile squadrons of the Lacedemonians.[1]

There is also good evidence to show that the method of transferring and cancelling the debts of parties residing at a distance by means of letters of credit, which are in effect the same as bills of exchange, was not unknown to the Romans. Cicero, in one of his epistles to Atticus,[2] inquires whether his son must carry cash to defray the expense of his studies with him to Athens, or whether he might not save this trouble and risk by obtaining an assignment for an equivalent sum from a creditor in Rome on his debtor in Athens. It is evident, from a subsequent epistle of Cicero, that the latter method had been preferred, and that the transference of the money had, in consequence, been rendered unnecessary.[3]

Macpherson states,[4] that the first mention of bills of exchange in modern history occurs in 1255. The pope, having quarrelled with Manfred, king of Sicily, engaged, on Henry III. of England agreeing to indemnify him for the expense, to depose Manfred, and raise Henry's second son, Edmund, to the Sicilian throne. The enterprise misgave. But the merchants of Sienna and Florence, who originally advanced the money to carry it into effect, or rather to gratify the pope's rapacity, were paid by bills drawn on the prelates of England, who, although they protested that they knew nothing at all about the transaction, were nevertheless compelled, under pain of excommunication, to pay the bills and interest![5]

Capmany, in his "Memoirs" respecting the Commerce, &c., of Barcelona, gives a copy of an ordonnance of the magistracy, dated in 1394, enacting that bills should be accepted within twenty-four hours after their presentation; a sufficient proof that they were in general use in the end of the fourteenth century.

But whatever be the æra of the introduction of bills of exchange, few inventions have redounded more to the public advantage. Without this simple and ingenious contrivance, commerce could have made no great progress. Had there been no means of adjusting the mutual claims of debtors and creditors otherwise than by the intervention of metallic money (for bank paper is only another species of bills of exchange), a very large portion of that capital which is setting productive labour in motion in every quarter of the globe, and ministering to the wants and enjoyments of mankind, must have been employed in effecting those exchanges which are much better effected by the agency of a few quires of paper. Instead of a perpetual importation and exportation of gold and silver, necessarily attended with an immensity of trouble and expense, bills, possessing little or no intrinsic worth, and which are transferred with the utmost facility, suffice to adjust the most extensive and complicated transactions. But the mere setting free of an immense productive power, engaged in a comparatively unprofitable employment, is only one of the many benefits we owe to the use of bills. By cheapening the instruments by which commerce is carried on, they have materially reduced the prices of most articles. And have, in consequence, increased the command of all classes over necessaries and luxuries, and accelerated the progress of civilization, by occasioning a more extensive intercourse and intimate connection between different and independent countries than would otherwise have taken place.

In a political point of view their effects have been equally salutary. They enable individuals imperceptibly to transfer their fortune to other countries, and to preserve it safe alike from the rapacity of their own governments and the hostile attacks of others. The security of property has, in consequence, been vastly augmented. And though we should concede to the satirist that paper credit has "lent corruption lighter wings to fly,"[6] it has, at the same time, powerfully contributed to render subjects less dependent on the policy, and less liable to be injuriously affected by the injudicious measures of their rulers. In countries in a low stage of civilization the inhabitants endeavour, by burying all the gold and silver they can collect, to preserve a part of their property from the despots by whom they are alternately plundered and oppressed. This was universally the case in the middle ages; and in Turkey, India, Persia, and other eastern, and also in some European, countries, the practice is still carried on to a greater or less extent. Some economists have endeavoured to account for the long-continued importation and high value of the precious metals in India, by the loss which necessarily attends the practice of hoarding; and undoubtedly this locking-up of capital, while it evinces an extreme degree of insecurity, is a main cause of the poverty of these countries. But the security afforded by bills of exchange is infinitely greater than any which can be derived from the barbarous expediment of trusting property to the bosom of the earth. "Pregnant with thousands flits the *scrap* unseen," and in a moment places the largest fortune beyond the reach of danger. Mr Harris was therefore right in saying, "that the introduction of bills of exchange was the greatest security to merchants, both as to their persons and effects, and consequently the greatest encouragement to commerce, and the greatest blow to despotism, of anything that ever was invented."[7]

[1] De Pauw, *Recherches sur les Grècs*, i., 258.

[2] *Epist. ad Atticum*, xii., 24.

[3] *Epist. ad Atticum*, xii. 27. "De Cicerone, ut scribis, ita faciam: ipsi permittam de tempore: nummorum quantum opus erit ut *permutetur* tu videbis." In his notes on a parallel passage, Grævius remarks, "*Permutatio* est quod nunc barbare *cambium* dicitur."—*Epist. ad Atticum*, xi. 24.

[4] *Annals of Commerce*, i., 405.

[5] Hume's *England*, cap. 12.

[6] "Blest paper credit! last and best supply!
That lends corruption lighter wings to fly!
Gold, imp'd by thee, can compass hardest things,
Can pocket states, can fetch or carry kings;
A single leaf shall waft an army o'er,
Or ship of senates, to some distant shore;
A leaf, like Sibyll's, scatter to and fro
Our fates and fortunes, as the wind shall blow;
Pregnant with thousands, flits the scrap unseen,
And silent sells a king, or buys a queen."—POPE.

[7] Harris *on Coins*, part i, p. 108.

Its extensive commerce, the wealth and punctuality of its merchants, and their intimate connection with all the other great trading cities of the world, made Amsterdam, previously to the peace of 1763, the chief place where the accounts of commercial countries were balanced and adjusted. But the loss of foreign trade, and the other vexations to which Holland was subjected during the ascendancy of the French, nearly divested Amsterdam of all share in this business; and it has not since recovered its former superiority. London is now the trading metropolis of Europe and of the world, *universi orbis terrarum emporium.* The vast extent of its commercial dealings necessarily renders it the great mart for bills of exchange. Its bill-merchants, a class of men remarkable for their shrewdness, and generally possessed of large capitals, assist in trimming and adjusting the balance of debt and credit between the most remote countries. They buy up bills where they are cheap, and sell them where they are dear, and, by the extent of their correspondence and the magnitude of their transactions, give a steadiness to the exchange to which it could not otherwise attain.

NEGOTIATION OF BILLS OF EXCHANGE.

Negotiation of bills of exchange.

Bills of exchange may be made payable on *demand* (the invariable term of payment in the case of checks), at *sight*, at a certain specified time *after sight* or *after date*, or at *usance*, which is the usual term allowed by the custom or law of the place where the bill is payable. Generally, however, a few days are allowed for payment beyond the term when the bill becomes due, which are denominated *days of grace*, and which vary in different countries. In Great Britain and Ireland, *three* days' grace are allowed on all bills except those payable on demand, which must be paid as soon as presented. The following is a statement of the usance and days of grace for bills drawn upon some of the principal commercial cities:—

[*m/d. m/s. d/d. d/s. d/a.* respectively denote *months after date, months after sight, days after date, days after sight, days after acceptance.*]

London on	Usance.	Days of Grace
Amsterdam	1 m/d.	0
Rotterdam	1 m/d.	0
Antwerp	1 m/d.	0
Hamburg	1 m/d.	12
Altona	1 m/d.	12
Dantzic	14 d/a.	10
Paris*	30 d/d.	0
Frankfort	14 d/s.	4
Bremen	1 m/d.	8
Barcelona	60 d/d.	14
Geneva	30 d/d.	5
Madrid	2 m/s.	14
Cadiz	60 d/d.	6
Bilboa	2 m/d.	14
Gibraltar	2 m/s.	14
Leghorn	3 m/d.	0
Leipzig	14 d/a.	0
Genoa	3 m/d.	30
Venice	3 m/d.	6
Vienna†	14 d/a.	3
Malta	30 d/d.	13
Naples	3 m/d.	3
Palermo	3 m/d.	0
Lisbon	30 d/s.	6
Oporto	30 d/s.	6
Rio Janeiro	30 d/d.	6
Dublin	21 d/s.	3
New York	60 d/s.	3

* In France, days of grace were suppressed by the *Code de Commerce*, art. 135.

† In Austria, bills payable at sight, or on demand, or at less than 7 days after sight or date, are not allowed any days of grace. In Petersburg, bills after date are allowed 10 days' grace, but after sight only 3 days' do.

In the dating of bills, the new style is used in every country of Europe, with the exception of Russia.

In London bills of exchange are bought and sold by brokers, who go round to the principal merchants and discover whether they are buyers or sellers of bills. A few of the brokers of most influence, after ascertaining the state of the relative supply and demand for bills, suggest a price at which the greater part of the transactions of the day are settled, with such deviations as particular bills, from their being in very high or low credit, may be subject to. The price fixed by the brokers is that which is published in Wittenhall's List; but the first houses generally negotiate their bills on ½, 1, 1½, and 2 *per cent.* better terms than those quoted. In London and other great commercial cities a class of middlemen speculate largely on the rise and fall of the exchange; buying bills when they expect a rise, and selling them when a fall is anticipated.

It is usual, in drawing foreign bills of exchange, to draw them in sets, or duplicates, lest the first should be lost or miscarry. When bills are drawn in sets, each must contain a condition that it shall be payable only while the others remain unpaid: thus, the first is payable only, "second and third unpaid;" the second, "first and third being unpaid;" and the third, "first and second unpaid."

All bills of exchange must be drawn upon stamps as under:—

INLAND BILL OF EXCHANGE, Draft, or Order, for the Payment to the Bearer, or to Order, at any Time otherwise than on Demand, of any Sum of Money

	L.	s.	d.
Not exceeding L.5	0	0	1
Exceeding L.5 and not exceeding 10	0	0	2
... 10 25	0	0	3
... 25 50	0	0	6
... 50 75	0	0	9
... 75 100	0	1	0
... 100 200	0	2	0
... 200 300	0	3	0
... 300 400	0	4	0
... 400 500	0	5	0
... 500 750	0	7	6
... 750 1000	0	10	0
... 1000 1500	0	15	0
... 1500 2000	1	0	0
... 2000 3000	1	10	0
... 3000 4000	2	0	0
... 4000 and upwards	2	5	0

FOREIGN BILL OF EXCHANGE drawn in, but payable out of, the U. K.

If drawn singly or otherwise than in a Set of Three or more, the same duty as on an Inland Bill of the same Amount and Tenor.

If drawn in Sets of Three or more, for every Bill of each Set.

	L.	s.	d.
Where the Sum payable thereby shall not exceed L.25	0	0	1
And where it shall exceed, L.25 and not exceed, 50	0	0	2
... ... 50 ... 75	0	0	3
... ... 75 ... 100	0	0	4
... ... 100 ... 200	0	0	8
... ... 200 ... 300	0	1	0
... ... 300 ... 400	0	1	4
... ... 400 ... 500	0	1	8
... ... 500 ... 750	0	2	6
... ... 750 ... 1000	0	3	4
... ... 1000 ... 1500	0	5	0
... ... 1500 ... 2000	0	6	8
... ... 2000 ... 3000	0	10	0
... ... 3000 ... 4000	0	13	4
... ... 4000 and upwards	0	15	0

FOREIGN BILL OF EXCHANGE drawn out of the U. K., and payable within the U. K., the same Duty as on an Inland Bill of the same Amount and Tenor.

FOREIGN BILL OF EXCHANGE drawn out of the U. K., and payable out of the U. K., but indorsed or negotiated within the U. K., the same Duty as on a Foreign Bill drawn within the U. K., and payable out of the U. K.

The Act 17th and 18th Vict., cap. 83, § 3, directs that

the duties on bills of exchange shall be denoted by adhesive stamps, to be furnished by the Commissioners of Inland Revenue.

Bills of exchange purporting to be drawn at any place out of the United Kingdom are to be deemed to be foreign bills, and are to be liable to the stamp-duty on such bills, though they may, in fact, have been drawn in the United Kingdom.—§ 4.

The holders of foreign bills, or bills drawn out of the United Kingdom, are to affix proper adhesive stamps to the same before negotiating them, under a penalty of L.50.—§ 5.

No one acquainted with the fundamental rules of arithmetic can have any difficulty whatever in estimating how much a sum of money in one country is worth in another, according to the state of the exchange at the time. The common arithmetical books abound in examples of such computations. But in conducting the business of exchange a direct remittance is not always preferred. When a merchant in London, for example, means to discharge a debt due by him in Paris, it is his business to ascertain not only the state of the direct exchange between London and Paris, and, consequently, the sum which he must pay in London for a bill on Paris equivalent to his debt, but also the state of the exchange between London and Hamburg, Hamburg and Paris, &c.; for it frequently happens that it may be more advantageous for him to buy a bill on Hamburg, Amsterdam, or Lisbon, and to direct his agent to invest the proceeds in a bill on Paris, rather than remit directly to the latter. This is termed the ARBITRATION of exchange. An example or two will suffice to show the principle on which it is conducted.

Thus, if the exchange between London and Amsterdam be 35s. Flemish (old coinage) per pound sterling, and between Paris and Amsterdam 1s. 6d. Flemish per franc, then, in order to ascertain whether a direct or indirect remittance to Paris would be most advantageous, we must calculate what would be the value of the franc in English money if the remittance were made through Holland; for if it be less than that resulting from the direct exchange, it will obviously be the preferable mode of remitting. This is determined by stating, as 35s. Flem. (the Amsterdam currency in a pound sterling): 1s. 6d. Flem. (Amsterdam currency in a franc) : : L.1 : 10d. the proportional or *arbitrated* value of the franc.—Hence, if the English money, or bill of exchange, to pay a debt in Paris, were remitted by Amsterdam, it would require 10d. to discharge a debt of a franc, or L.1 to discharge a debt of 24 francs: and therefore, if the exchange between London and Paris were at 24, it would be indifferent to the English merchant whether he remitted directly to Paris, or indirectly *viâ* Amsterdam; but if the exchange between London and Paris were *above* 24, then a direct remittance would be preferable; while, if, on the other hand, the direct exchange were less than 24, the indirect remittance ought as plainly to be preferred.

"Suppose," to borrow an example from Kelly (*Universal Cambist*, vol. ii., p. 137), "the exchange of London and Lisbon to be at 68d. per milree, and that of Lisbon on Madrid 500 rees per dollar, the arbitrated price between London and Madrid is 34d. sterling per dollar; for, as 1000 rees : 68d. : : 500 rees : 34d. But if the direct exchange of London on Madrid be 35d. sterling per dollar, then London, by remitting directly to Madrid, must pay 35d. for every dollar; whereas, by remitting through Lisbon, he will pay only 34d.: it is therefore the interest of London to remit indirectly to Madrid through Lisbon. On the other hand, if London draws directly on Madrid, he will receive 35d. sterling per dollar; whereas, by drawing indirectly through Lisbon, he would receive only 34d.; it is therefore the interest of London to draw directly on Madrid. Hence the following rules:—

"1. Where the certain price is given, draw through the place which produces the lowest arbitrated price, and remit through that which produces the highest.

"2. Where the uncertain price is given, draw through that place which produces the highest arbitrated price, and remit through that which produces the lowest."

In compound arbitration, or when more than three places are concerned, then, in order to find how much a remittance passing through them all will amount to in the last place, or, which is the same thing, to find the arbitrated price between the first and the last, we have only to repeat the different statements in the same manner as in the foregoing examples.

Thus, if the exchange between London and Amsterdam be 35s. Flem. for L.1 sterling; between Amsterdam and Lisbon 42d. Flem. for 1 old crusade; and between Lisbon and Paris 480 rees for 3 francs: what is the arbitrated price between London and Paris?

In the first place, as 35s. Flem. : L.1 : : 42d. Flem. : 2s. sterling = 1 old crusade.

Second, as 1 old crusade, or 400 rees : 2s. sterling : : 480 rees : 2s. 4·8d. sterling = 3 francs.

Third, as 2s. 4·8d. sterling : 3 francs : : L.1 sterling : 25 francs, the arbitrated price of the pound sterling between London and Paris.

This operation may be abridged as follows:—

		L.1 sterling.
L.1 sterling	=	35s. Flemish.
$3\frac{1}{2}$ shillings Flem.	=	1 old crusade.
1 old crusade	=	400 rees.
480 rees	=	3 francs.

$$\text{Hence } \frac{35 \times 400 \times 3}{480 \times 3\frac{1}{2}} = \frac{4200}{168} = 25 \text{ francs.}$$

This abridged operation evidently consists in aranging the terms so that those which would form the divisors in continued statements in the Rule of Three are multiplied together for a common divisor, and the other terms for a common dividend. The ordinary arithmetical books abound with examples of such operations.

The following account of the manner in which a very large transaction was actually conducted by indirect remittances, will sufficiently illustrate the principles we have been endeavouring to explain.

In 1804, Spain was bound to pay to France a large subsidy; and, in order to do this, three distinct methods presented themselves:—

1. To send dollars to Paris by land.
2. To remit bills of exchange directly to Paris.
3. To authorise Paris to draw directly on Spain.

The first of these methods was tried, but it was found too slow and expensive; and the second and third plans were considered likely to turn the exchange against Spain. The following method by the indirect or circular exchange was therefore adopted.

A merchant or *banquier* at Paris was appointed to manage the operation, which he thus conducted:—He chose London, Amsterdam, Hamburg, Cadiz, Madrid, and Paris, as the principal hinges on which the operation was to turn; and he engaged correspondents in each of these cities to support the circulation. Madrid and Cadiz were the places in Spain from whence remittances were to be made; and dollars were, of course, to be sent to where they bore the highest price, for which bills were to be procured on Paris, or on any other places that might be deemed more advantageous.

The principle being thus established, it only remained to regulate the extent of the operation, so as not to issue too much paper on Spain, and to give the circulation as much support as possible from real business. With this view, London was chosen as a place to which the operation might be chiefly directed, as the price of dollars was then high in England; a circumstance which rendered the proportional exchange advantageous to Spain.

The business was commenced at Paris, where the negotiation of drafts issued on Hamburg and Amsterdam served to answer the immediate demands of the state; and orders were transmitted to these places to draw for the reimbursements on London, Madrid, or Cadiz, according as the course of exchange was most favourable. The proceedings were all conducted with judgment, and attended with complete success. At the commencement of the operation, the course of exchange of Cadiz on London was 36d.; but by the plan adopted, Spain got $39\frac{1}{2}$d., or above 8 *per cent.* by the remittance of dollars to London, and considerable advantages were also gained by the circulation of bills through the several places on the Continent.—(*Kelly's Cambist*, vol. ii., p. 168; *Dubost's Elements of Commerce*, 2d ed., p. 228.)

 Table specifying the Value of the Monies of Account of the principal Places with which this Country has Exchange Transactions, taking Silver at 5s. an oz., and specifying also the Par *of Exchange with such Places on this Hypothesis.*—(Abstracted from *Tate's Modern Cambist,* to which the reader is referred for farther explanations.) Exchange.

							Par of Exchange.		
Petersburg	100 copecks	=	1 rouble	=	3s. $1\frac{1}{2}$d.	giving	6 roub. 40 cop.	=	L.1
Berlin	30 sil. groschen	=	1 Pruss. doll.	=	2s. $10\frac{3}{4}$d.	—	6 doll. 27 s. g.	=	1
Copenhagen	96 skillings	=	1 Rig. doll.	=	2s. $2\frac{1}{3}$d.	—	9 doll. 10 sk.	=	1
Hamburg	16 schillings	=	1 mark	=	1s. $5\frac{1}{2}$d.	—	13 mks. $10\frac{1}{2}$ sch.	=	1
Amsterdam	100 centimes	=	1 florin	=	1s. 8d.	—	11 fl. 97 cents	=	1
Antwerp	100 centimes	=	1 florin	=	1s. 8d.	—	11 fl. 97 cents	=	1
Paris	100 centimes	=	1 franc	=	$9\frac{1}{2}$d.	—	25 fr. 57 cents	=	1
Frankfort	$24\frac{1}{2}$ guld. or flor.	=	1 mark	=	1s. $7\frac{7}{8}$d.	—	$12\frac{3}{40}$ guldens	=	1
Vienna	60 kreusers	=	1 florin	=	2s. $0\frac{4}{10}$d.	—	9 fl. 50 kr.	=	1
Venice	100 centisimi	=	1 lira Austriaca	=	8·13d.	—	29 li. 52 cent.	=	1
Genoa	100 centisimi	=	1 lira Nuova	=	$9\frac{1}{2}$d.	—	25 li. 57 cent.	=	1
Leghorn	100 centisimi	=	1 lira Toscana	=	7·82d.	—	30 li. 69 cent.	=	1
Madrid	8 reals	=	1 dollar of Plate	=	3s. $1\frac{3}{4}$d.	—	6 doll. $2\frac{3}{4}$ reals	=	1
Lisbon	1000 reis	=	1 milreis	=	4s. 8d.	—	4 mil. 285 reis	=	1
New York	100 cents	=	1 dollar	=	4s. 2d.	—	4 doll. 80 cents	=	1
Rio Janeiro	1000 reis	=	1 milreis	=	2s. 7d.	—	7 mill. 777 reis	=	1
Havannah	100 cents	=	1 dollar	=	4s. $6\frac{13}{222}$d.	—	4 doll. 44 cents	=	1

It is easy from this table to calculate the value of any of the above coins, taking silver at 5s. 2d., 5s. 6d. an oz., or any other price, and thence to deduce the par of exchange at such rates.

LAW OF BILLS OF EXCHANGE.

The chief legal privileges appertaining to bills are, first, that though only a simple contract, yet they are always presumed to have been originally given for a good and valuable consideration; and, secondly, they are assignable to a third person not named in the bill or party to the contract, so as to vest in the assignee a right of action, in his own name; which right of action, no release by the drawer to the acceptor, nor set-off or cross demand due from the former to the latter, can affect.

All persons, whether merchants or not, being legally qualified to contract, may be parties to a bill. But no action can be supported against a person incapable of binding himself, on a bill drawn, indorsed, or accepted by such incapacitated person; at the same time the bill is good against all other competent parties thereto.

Bills may be drawn, accepted, or indorsed by the party's agent or attorney verbally authorized for the purpose. When a person has such authority, he must either write the name of his principal, or state in writing that he draws, &c., as agent, thus: "per procuration, for A. B."

Where one of several partners accepts a bill drawn on the firm, for himself and partners, or in his own name only, such acceptance binds the partnership if it concerns the trade. But the acceptance of one of several partners on behalf of himself and partners, will not bind the others, if it concern the acceptor only in a separate and distinct interest; and the holder of the bill, at the time he becomes so, was aware of that circumstance. If, however, he be a *bona fide* holder for a sufficient consideration, and had no such knowledge at the time he first became possessed of the bill, no subsequently acquired knowledge of the misconduct of the partner in giving such security will prevent him from recovering on such bills against all the partners.

Although no precise form of words is required to constitute a bill of exchange or promissory note, yet it is necessary that it should be *payable at all events,* and not depend on any contingency; and that it be made for the payment of money only, and not for payment of money and performance of some other act, as the delivery of a horse, or the like.

If, however, the event on which the payment is to depend must inevitably happen, it is of no importance how long the payment may be in suspense; so a bill is negotiable and valid if drawn payable six weeks after the death of the drawer's father, or payable to an infant when he shall become of age.

Any material alteration of a bill after it has been drawn, accepted, or indorsed, such as the date, sum, or time of payment, will invalidate it; but the mere correction of a mistake, as by inserting the words "or order," will have no such effect.

The negotiability of a bill depends on the insertion of sufficient operative words of transfer; such as by making it payable to A. or order, or to A. or bearer, or to bearer generally.

Although a bill is presumed to have been originally drawn upon a good and valuable consideration, yet in certain cases a want of sufficient consideration may be insisted on in defence to an action on a bill. Certain considerations have been made illegal by statute; as for signing a bankrupt's certificate, for money won at gaming, or for money lent on a usurious contract. But with respect to gaming, it is held that a bill founded on a gambling transaction is good in the hands of a *bona fide* holder; and by 58th Geo. III., cap. 93, a bill or note in the hands of an innocent holder, although originally founded on a usurious contract, is not invalid.

In general, if a bill is fair and legal in its origin, a subsequent illegal contract or consideration on the indorsement thereof will not invalidate it in the hands of a *bona fide* holder.

A bill cannot be given in evidence in a court of justice, unless it be duly stamped, not only with a stamp of the proper value, but also of the proper denomination.

Acceptance of a Bill.—An acceptance is an engagement to pay a bill according to the tenor of the acceptance, which may be either *absolute* or *qualified.* An *absolute* acceptance is an engagement to pay a bill according to its request, which is done by the drawee writing "Accepted" on the bill, and subscribing his name, or writing "Accepted" only; or merely subscribing his name at the bottom or across the bill. A *qualified* acceptance is when a bill is accepted conditionally; as when goods conveyed to the drawee are sold, or when a navy bill is paid, or other future event which does not bind the acceptor till the contingency has happened.

An acceptance may be also partial; as to pay L.100 instead of L.150, or to pay at a different time or place from that required by the bill. But in all cases of a conditional or partial acceptance, the holder should, if he mean to resort to the other parties to the bill in default of payment, give notice to them of such partial or conditional acceptance.

In all cases of presenting a bill for acceptance, it is necessary to present the bill at the house where the drawee lives, or where it is made payable. By 1st and 2d Geo. IV., cap. 78, all bills accepted payable at a banker's or other place are to be deemed a general acceptance; but if they are accepted payable at a banker's "only and not otherwise or elsewhere," it is a qualified acceptance, and the acceptor is not liable to pay the bill, except in default of payment when such payment shall have been first demanded at the banker's. The drawee is entitled to keep the bill twenty-four hours when presented for acceptance. The acceptance of an inland bill must be *in writing on the face of the bill,* or if there be more parts than one, on one of such parts; nothing short of this constitutes a valid acceptance.

When a bill is made payable *at sight,* or at a certain time *after sight,* it must, in either case, in order to fix the time when it is to be paid, be presented for acceptance; and the date of the acceptance should appear thus: "Accepted, 10th May 1855."

Due diligence is the only thing to be considered in presenting any description of bill for acceptance; and such diligence is a question depending on the situation of the parties, the distance at which they live, and the facility of communication between them.

When the drawee refuses to accept, any third party, after protesting, may accept for the honour of the bill generally, or for the drawee, or for the indorser; in which case the acceptance is called an acceptance *supra protest.*

The drawers and indorsers are discharged from liability, unless due notice of non-acceptance when presented for acceptance, or non-payment at the time the bill becomes due, is given. These notices must be given with all due diligence to all the parties to whom the holder means to resort for payment. Generally, in both foreign and inland bills, notice is given next day to the immediate indorser, and such indorser is allowed a day, when he should give fresh notice to the parties who are liable to him.

Notice may be sent by the post, however near the residence of the parties may be to each other; and though the letter containing such notice should miscarry, yet it will be sufficient; but the letter containing the notice should be delivered at the General Post Office, or at a receiving-house appointed by that office, not to the bellman

in the street. In all cases of notice, notice to one of several parties is held to be notice to all; and if one of several drawers be also the acceptor, it is not necessary to give notice to the other drawers.

Upon the non-acceptance or non-payment of a bill, the holder, or a public notary for him, should protest it; that is, draw up a notice of the refusal to accept or pay the bill, and the declaration of the holder against sustaining loss thereby. Inland bills need not be protested; in practice they are usually only noted for non-acceptance; but this, without the protest, is wholly futile, and adds nothing whatever to the evidence of the holder, while it entails a useless expense on those liable to pay.

Indorsement of Bills.—An indorsement is the act by which the holder of a negotiable instrument transfers his right to another person, termed the indorsee. It is usually made on the back of a bill, and must be in writing; but the law has not prescribed any set form of words as necessary to the ceremony, and in general the mere signature of the indorser is sufficient.

All bills payable to order or to bearer for L.1 and upwards are negotiable by indorsement; and the transfer of them for a good consideration before they are payable gives a right of action against all the precedent parties on the bill, if the bills in themselves are valid; but a transfer after they are due will only place the holder in the situation of the person from whom he takes them.

Bills may be transferred either by delivery only, or by indorsement and delivery; bills payable to order are transferred by the latter mode only; but bills payable to bearer may be transferred by either mode. On a transfer by delivery, the person making it ceases to be a party to the bill; but on a transfer by indorsement, he is to all intents and purposes chargeable as a new drawer.

A bill originally transferable may be restrained by restrictive words; for the payee or indorsee, having the absolute property in the bill, may, by express words, restrict its currency, by indorsing it "Payable to A. B. only," or "to A. B. for his use," or any other words clearly demonstrating his intention to make a restrictive and limited indorsement. Such special indorsement precludes the person in whose favour it is made from making a transfer, so as to give a right of action against the special indorser, or any of the precedent parties to the bill.

In taking bills to account or discount, it is important well to examine all special indorsements. Lord Tenterden decided that a person who discounts a bill indorsed "Pay to A. B. or order *for my use*," discounts it subject to the risk of having to pay the money to the special indorser, who so limited the application *for my use;* thus a party may be liable to pay the amount of the bill twice over, unless he previously ascertains that the payment has been made conformably to the import of the indorsement.

After the payment of part, a bill may be indorsed over for the residue.

Presentment for Payment.—The holder of a bill must be careful to present it for payment at the time when due, or the drawer and indorsers will be exonerated from their liability; even the bankruptcy, insolvency, or death of the acceptor, will not excuse a neglect to make presentment to the assignees or executor; nor will the insufficiency of a bill in any respect constitute an excuse for non-presentment: the presentment should be made at a reasonable time of the day when the bill is due; and if by the known custom of any trade or place bills are payable only within particular hours, a presentment must be within those hours. If a bill has a qualified acceptance, the presentment should be at the place mentioned in such qualified acceptance, or all the parties will be discharged from their obligations.

If a bill fall due on Sunday, Good Friday, Christmas Day, or any public fast or thanksgiving day, the presentment must be on the day preceding these holidays. By 7th and 8th Geo. IV., cap. 15, if a bill or note be payable on the day preceding these holidays, notice of the dishonour may be given the day following the holiday; and if Christmas Day fall on Monday, notice may be given on Tuesday.

Bills, however, payable at usance, or at a certain time after date or sight, or after demand, ought not to be presented for payment precisely at the expiration of the time mentioned in the bills, but at the expiration of what are termed *days of grace.* The days of grace allowed vary in different countries, and ought always to be computed according to the usage of the place where the bill is due. In some countries, as in France, they have been abolished. At Hamburg, the day on which the bill falls due makes one of the days of grace; but nowhere else.

On bills payable on demand, or when no time of payment is expressed, no days of grace are allowed; but they are payable instantly on presentment. On bank post bills no days of grace are claimed; but on bills payable at sight the usual days of grace are allowed from the sight or demand, as notified by the date of the acceptance.

Payment of a bill should be made only to the holder; and it may be refused unless the bill be produced and delivered up. On payment, a receipt should be written on the back; and when a part is paid, the same should be acknowledged upon the bill, or the party paying may be liable to pay the amount a second time to a *bona fide* indorser.

Promissory Notes and Checks.—The chief distinction between promissory notes and bills of exchange is, that the former are a direct engagement by the drawer to pay them according to their tenor, without the intervention of a third party as a drawee or acceptor. Promissory notes may be drawn payable on demand to a person named therein, or to order, or to bearer generally. They are assignable and indorsable; and in all respects so nearly assimilated to bills, that the laws which have been stated as bearing upon the latter may be generally understood as applicable to the former. It has been decided, in case an instrument is drawn so equivocally as to render it uncertain whether it be a bill of exchange or promissory note, the holder may treat it as either against the drawer.

The issue of any promissory note payable to bearer on demand for a less sum than L.5 by the Bank of England, or any licensed English banker, is prohibited; and by 9th Geo. IV., cap. 65, it is provided, that no corporation or person shall utter or negotiate, in England, any such note which has been made or issued in Scotland, Ireland, or elsewhere, under a penalty not exceeding L.20 nor less than L.5. But this does not extend to any draft or order on bankers for the use of the drawer.

A *check or draft* is as negotiable as a bill of exchange, and vests in the assignee the same right of action against the assignor. If not presented within a reasonable time, payment may be refused.

Unstamped drafts or orders for any sum of money payable to bearer on demand, may be drawn upon bankers, or persons acting as such, provided the place where they transact business, or where the drafts or orders are to be paid, be within 15 miles of the place where they are issued. But all such drafts or orders when remitted or sent to any greater distance than 15 miles from their place of issue, must be duly stamped under a penalty of L.50 (17th and 18th Vict., cap. 83, sect. 6).

Any person making, accepting, or paying any bill, draft, order, or promissory note, not duly stamped, is liable to a penalty of L.50; for post-dating them, L.100; and for not truly specifying the place where unstamped drafts are issued, L.100; and any person knowingly receiving such unstamped draft, L.20; and the banker knowingly paying it, L.100; besides not being allowed such sum in account.

It used to be of especial importance to bankers and others taking bills and notes, that they should not only be aware of the responsibility of the acceptors and other parties to such bills and notes, but that they should have some knowledge of those from whom they received them; for, if the instrument turned out to have been lost or fraudulently obtained, they might be deprived of their security, on an action by the owner to recover possession. Lord Tenterden decided, "if a person take a bill, note, or any other kind of security, under circumstances which ought to excite suspicion in the mind of any reasonable man acquainted with the ordinary affairs of life, and which ought to put him on his guard to make the necessary inquiries, and he do not, then he loses the right of maintaining possession of the instrument against the rightful owner."—(*Guildhall*, Oct. 25, 1826.) But it has since been decided, in contravention of this doctrine, that the claim of the *bona fide* holder of a bill or note that has been lost or stolen is not invalidated by the want of the suspicions or inquiries referred to by Lord Tenterden, or even by gross negligence; and that to defeat the holder's claim it must be shown that he took the instrument *mala fide.*—(*Chitty on Bills*, 9th ed. p. 257.) This is not only an important, but, as we think, a sound decision: it facilitates the negotiation of bills, and clears up and gives precision to the law.

Before concluding this article on mercantile paper, it may not be improper to introduce one or two cautions with regard to acceptances, and accommodation paper, and proceedings in case of the loss of bills.

First, A man should not put his name as acceptor to a bill of exchange without well considering whether he has the means of paying the same when due, as otherwise he may be liable not only to the costs of the action against himself, but also to the costs of the action against the other parties to the bill: the shrewd tradesman is generally anxious to get the acceptance of his debtor at a short date, well knowing that it not only fixes the amount of the debt, but is more speedily recoverable by legal procedure than a book debt.

Secondly, Traders who wish to support their respectability, and desire to succeed in business, should be cautious in resorting to what is called the system of cross-accommodation acceptances: it seldom ends well, and usually excites suspicion as to the integrity of the parties; it being an expedient often adopted by swindlers to defraud the public. Independent of the expense in stamps and discounts, and frequently in noting, interest, and law expenses, the

danger attending such accommodation is sufficient to deter from the practice. Suppose, for instance, A. and B. mutually accommodate each other to the amount of L.1000, the acceptances being in the hands of third persons; both A. and B. are liable to such third persons to the extent of L.2000 each; and should A. by any unforseen occurrence be suddenly rendered unable to meet his acceptances, the holders of the whole, as well the acceptances of A. as the acceptances of B., will resort to B. for payment; and it may so happen, that although B. could have provided for his own share of the accommodation paper, he may be unable to provide for the whole, and may thus become insolvent.

Lastly, In case of the loss of a bill, the 9th and 10th Will. III., cap. 17, provides, that if any inland bill be lost or missing within the time limited for its payment, the drawer shall, on sufficient security given to indemnify him if such bill be found again give another bill of the same tenor with the first. (J. R. M.)

EXCHANGE also signifies a place in most considerable trading cities where merchants, agents, bankers, brokers, interpreters, and other persons concerned in commerce, assemble on certain days, at a fixed hour, to confer together in regard to matters relating to exchanges, remittances, payments, assurances, freights, &c. In Flanders, Holland, and France, these places are called *Bourses*, or *Places de Change;* and in the Hanse Towns, *Borsenhalle.* The most considerable exchanges in Europe are those of London, Paris, and Amsterdam.

The ancient Romans had places for merchants to meet in most of the considerable cities of their empire. That which is said to have been built at Rome in the year B.C. 493 was called *Collegium Mercatorum,* of which it is alleged there are still some remains, called by the modern Romans *Loggia,* the Lodge, or place of St George.

EXCHEQUER BILLS are bills of credit issued by authority of parliament. They are, for various sums, and bear interest (generally from 1½d. to 2½d. per diem, per L.100) according to the usual rate at the time. The advances of the Bank to government are made upon Exchequer bills; and the daily transctions between the Bank and government are principally carried on through their intervention. Notice of the time at which outstanding Exchequer bills are to be paid off is given by public advertisement. Bankers prefer vesting in Exchequer bills to any other species of stock, even though the interest be for the most part comparatively low; because the capital may be received at the treasury at the rate originally paid for it, the holders being exempted from any risk of fluctuation, except in the amount of the premium or discount at which they may have bought the bills. Exchequer bills were first issued in 1696, and have been annually issued ever since. The subjoined is an account of the unfunded debt in Exchequer bills, and of the annual charge thereon, on the 5th of January 1817, and on the 5th of January in every subsequent year down to 1855.

Years ending Jan. 5.	Amount of Exchequer Bills.	Rate of Interest per Diem.	Charge of Interest per Annum.
	L.		L.
1817	44,650,300	3d. Nov. 22, 1816	2,173,927
1818	56,729,400	2½d. Feb. 24, 1817	1,891,315
1819	43,208,400	2d. Oct. 11, 1817	2,026,450
1820	36,303,200	... ...	847,091
1821	30,965,900	... ...	1,529,181
1822	31,566,550	... ...	2,009,311
1823	36,281,150	... ...	1,309,409
1824	34,741,750	1½d. June 24, 1824	1,111,220
1825	32,398,450	... ...	1,086,015
1826	27,994,200	2d. Dec. 19, 1825	820,000
1827	24,565,350	... ...	770,000
1828	27,546,850	... ...	802,186
1829	27,657,000	1¾d. Sept. 30, 1829	860,475
1830	25,490,550	1½d. Dec. 18, 1829	806,076
1831	27,271,650	... ...	726,465
1832	27,133,350	... ...	604,365
1833	27,278,000	... ...	577,320
1834	27,906,900	... ...	723,596
1835	28,521,550	... ...	636,417
1836	28,976,600	2d. Sept. 29, 1836	688,701
1837	26,976,000	2½d. Nov. 21, 1836	692,095
1838	24,044,550	2d. Dec. 14, 1837	871,309

Years ending Jan. 5.	Amount of Exchequer Bills.	Rate of Interest per Diem.	Charge of Interest per Annum.
	L.		L.
1839	24,026,050	1¾d. March 18, 1839	641,370
1840	19,965,050	2¼d. March 16, 1840	788,707
1841	21,076,350	... ...	559,130
1842	18,343,850	2d. June 15, 1842	797,046
1843	18,182,100	1¾d. March 17, 1843 1½d. June 16, 1843	631,601
1844	18,407,300	... ...	594,051
1845	18,404,500	... ...	462,363
1846	18,380,200	... ...	422,654
1847	18,310,700	2d. March 16, 3d. June 16, 1847	419,393
1848	17,946,500	2½d. March 16, 2d. June 15, 1848	433,348
1849	17,786,700	1½d. March 15, 1849	787,381
1850	17,758,700	... ...	605,124
1851	17,756,600	... ...	402,790
1852	17,742,800	1¼d. June 10, 1852	403,476
1853	17,742,500	1d. March 10, 1853 2d. Oct. 11, 1853	402,852
1854	16,029,600	2¼d. June 12, 1854	368,414
1855	17,183,000	... ...	348,513

The interest paid within each year is given in the column of charge, which interest has accrued upon the capital stated in the preceding year.

The interest upon the L.16,029,600, and upon L.1,750,000 of bills issued in April 1854, will be paid in 1855.

The interest upon the L.17,183,000, will not be payable till 1856, *i. e.*, year ending January 5, 1857.

In 1853 *Exchequer bonds* were issued bearing interest at 2¾ per cent. for ten years, and thereafter 2½ per cent. for thirty years, or till 1894, to such holders of South Sea, and 3 per cent. stock as chose to accept the same, a bond for L.100 being given for every L.100 stock subscribed (16th and 17th Vict., cap. 23). But only a very small sum (L.5000) has been invested in such bonds. (J. R. M.)

EXCHEQUER, COURT OF, an ancient court of record, so called from the chequered cloth, resembling a chess-board, which covered the table. This court was derived from the Normans, and was at first intended principally to order the revenues of the Crown, and to recover the king's debts and duties. The judges were styled *Barones Scaccarii,* and the court was anciently held in the king's palace. The common-law part of their jurisdiction was acquired by usurpation, as at first it was merely for the benefit of the king's accountants, but afterwards a legal fiction obtained whereby the plaintiff suggested he was the king's debtor, *quominus sufficiens existit:* by which he was less able to pay the king his debt. This suggestion not being controverted, the court became an ordinary court of justice between subject and subject, and at length by the Uniformity of Process Act, 2d Will. IV., cap. 39, a direct and proper jurisdiction was given without resorting to the legal fiction. There are two divisions of the court—the receipt of the Exchequer, managing the royal revenues,

and the judicial part of the court. Formerly the court of exchequer had power and jurisdiction as a court of equity, but the act 5th Vict., cap. 5, transferred this power to the court of chancery.

As a court of revenue it ascertains and enforces the rights of the crown against subjects, and as a court of common law it takes cognizance of all personal actions like the other courts, with the exception of a few species of real actions. There are at present five judges, the lord chief baron and four puisné barons. An appeal lies from the decision of this court to the court of exchequer chamber. The Chancellor of the Exchequer is the treasurer, and holds the seal of the court.

EXCHEQUER CHAMBER, Court of, was erected in England by the 31st Edw. III., cap. 12, to determine causes on writs of error from the common-law side of the court of exchequer, and consisted of the lord chancellor, the lord treasurer, and the justices of the king's bench and common pleas. By the 27th Eliz., cap. 8, a second court was established, consisting of the justices of the common pleas and the barons of the exchequer, to determine appeals from the king's bench. A new arrangement was made by the 11th Geo. IV., and 1 Will. IV., cap. 70, § 8, whereby the judgments of each of the superior common-law courts are subject to revision by the judges of the other two sitting as a court of error in the exchequer chamber. An appeal lies from this court to the House of Lords.

Exchequer, in Scotland. See Scotland.

EXCISE (most probably from the Latin *excidere, to cut off*), a term used in finance to signify a duty charged in a country upon articles produced in it before they are permitted to get into the possession of the public.

Some articles are much better suited than others for being subjected to excise duties. But they have been imposed on a great variety of articles, and have, for a lengthened period, furnished a large portion of the public revenue of most European countries.

Excise duties have, indeed, existed in one form or other in all modern, and perhaps also in all ancient, states. They were introduced into Rome by Augustus, who imposed a duty of one per cent. (*centesima rerum venalium*) on all articles, whether great or small, sold in public markets or by auction. Though extremely moderate, a duty of this sort could not fail, from the difficulties in the way of its assessment, its interference with the dealings of individuals, and the abuses to which it must have led, to occasion clamour and discontent. And these in no long time became so very prevalent, that Tiberius was obliged to declare that the maintenance of the army, for the support of which this tax had been appropriated, depended on its being continued. (Taciti *Annal.*, lib. i., § 78.) In the sequel it underwent various changes. It appears to be sufficiently well established that it applied only to Rome, and, perhaps, to some few of the other great towns. In the smaller towns its produce would not indeed have sufficed to defray the cost of its collection. It, therefore, had at bottom a good deal in common with the *octrois* or town duties charged on commodities coming into Paris and other great continental cities. But the defective mode of its assessment must have made it infinitely more troublesome and onerous. (Gibbon, *Decline and Fall*, i. 211, ed. 1838; Dureau de la Malle, *Economie Politique des Romains*, ii. 459, &c.)

It is said that the first attempt to introduce excise duties into England was made in 1626 by a commission under the Great Seal. But parliament having remonstrated against the measure, the commission was cancelled. This description of duties had, however, been previously established in Holland, and the large revenue which they afforded pointed them out to the leaders of the popular party in the great civil war as the most likely means by which they could raise funds to carry on the arduous contest in which they had embarked. They were, consequently, introduced by a parliamentary ordinance issued in 1643, which imposed duties on ale, beer, cider, and perry, and on the makers and venders thereof. The Royalists soon after followed the example set by the Republicans; though, as the duties were from the outset exceedingly unpopular, both parties took especial care to ascribe their introduction to necessity, and to pledge themselves to their abolition at the close of the war. But they were soon found to be far too productive to be voluntarily abandoned; and after the nation had been accustomed to them for a few years, and they had been considerably increased, parliament did not hesitate to declare in 1649 that "the impost of excise was the most easy and indifferent levy that could be laid upon the people." (Blackstone, book i., cap. 8.) And it is worthy of remark that the regulations embodied in Cromwell's Excise Act of 1657, authorizing officers to make searches, and directing the giving of notices, &c., are very similar to those now in force.

The same reasons that made the excise be continued down to the Restoration, secured its existence subsequently to that epoch. A portion of its produce was, at the same time, assigned in perpetuity to the crown, in compensation for its relinquishing the hereditary revenues arising from wardships and other feudal prerogatives which were then abolished. And, notwithstanding Blackstone says that, "from its first original to the present time, its very name has been odious to the people of England" (Com. *ubi supra*), it has continued progressively to gain ground; and has, for a lengthened series of years, furnished a large portion of the public revenue.

It is probable that the prejudice to which Blackstone alludes did not originate so much in any dislike to the duties themselves as in the peculiar circumstances connected with their imposition. Originally they were let in farm, which is always a most unpopular proceeding. And down to a recent period there was hardly a single duty the assessment of which was not made the subject of numerous lengthened, obscure, and contradictory statutes, so that it was hardly possible for any trader, however desirous to comply with the law, to avoid getting into serious scrapes. The duties being frequently, also, carried to an oppressive extent, smuggling was practised; and when a party was prosecuted, whether for an intentional or unintentional infraction of the law, or for attempting to defraud the revenue, the case might be laid before judges (without the intervention of a jury) in whose decision the public had little confidence. No wonder, therefore, that the excise should have been unpopular. But the obnoxious practice of letting the duties to farmers has been long abandoned, and of late years the laws and regulations connected with their assessment have been much simplified. In this respect, indeed, nothing should be omitted to render the rules for assessing the duties brief, level to the comprehension of every one, and calculated to interfere as little as possible with the details and processes of manufacture. And, supposing their assessment to be sufficiently simplified, and that they are of a reasonable amount, but little objection can be made to the duties because of the summary jurisdiction exercised by the commissioners and justices. On the contrary, this practice has some material advantages. When parties are prosecuted in the court of exchequer for offences against the revenue, their case is, of course, submitted to a jury. But in this court, as in others, delays frequently take place, and the expenses are always very considerable; whereas, in cases of summary jurisdiction, or those adjudged by the commissioners and justices, there is little or no delay, and little or no expense. And, considering that all parties who fancy themselves aggrieved by the decision of the commissioners are entitled (4th Vict., cap.

20, sec. 26), to appeal at a very trifling cost to a baron of exchequer, who rejudges the case; while those who suppose themselves aggrieved by a sentence of the justices may appeal to the quarter-sessions (7th and 8th Geo. IV., cap. 53, sec. 82), there really appears to be more to approve than to object to in the summary jurisdiction.

The excise duties formerly imposed on salt, leather, candles, beer, glass, and other less important articles, have been repealed within these few years. And we doubt whether there be one of the existing duties which can be fairly objected to on principle, or for its injuriously interfering with the manufacture, or being too high. Whatever may have been the case formerly, the excise is now fully entitled to the eulogium passed upon it by Arthur Young, "Excises are by much the fairest, most equal, and least burdensome of all taxes. They are paid voluntarily. Not a shilling is contributed but in proportion to the free consumption. The Dutch, who have been deservedly esteemed the wisest nation in Europe in all matters of taxation, have been enabled to preserve their industry under burdens of which we have no experience and scarcely any conception, principally by their having adopted this mode of taxation" (*Political Arithmetic*, part ii., p. 46). For farther information in regard to the excise duties, see art. TAXATION in this work. (J. R. M.)

EXCLUSION, BILL OF, in English history, a bill proposed towards the close of the reign of Charles II., for excluding his brother, the Duke of York, from the throne, on account of his being a Papist.

EXCOMMUNICATION, an ecclesiastical censure, by which, till it be removed, a person is excluded from communion with his church. It is founded on the natural right which all societies have to exclude from their body such as contravene the established laws. Hence this power has been exercised wherever societies have existed—secular, spiritual, literary, &c. It was in use among the Jews, who, in certain cases, excluded persons from communion in the benefits of religious worship with the people. Excommunication, or the act of excluding from a participation in the mysteries of religion, was also in use under Paganism. Persons thus excommunicated were prohibited from assisting at or attending the sacrifices, or entering the temples, and were solemnly given over to the infernal deities with certain imprecations. This was called by the Romans *diris devovere*. Among the ancient Britons and Gauls the Druids likewise made use of excommunication against rebels, and interdicted from the communion of their mysteries such as refused to acquiesce in their decisions. Among the early Christians excommunication was instituted for the purpose of preserving the purity of the church, and enforcing its discipline. It was originally exercised by the whole community, but afterwards the right to excommunicate was confined to the bishops. This formidable power, however, soon came to be wielded with little discretion, and eventually ambitious ecclesiastics converted it into an engine for aggrandizing themselves, frequently inflicting it on the most frivolous pretences. In the Roman Church, since the time of Pope Gregory IX., there have existed two kinds or rather degrees of excommunication—the greater and the less. By the former, parties are deprived of the sacraments and benefit of divine offices, of the society and conversation of the faithful, and are denied Christian burial. In the case of an excommunicated sovereign, subjects were absolved from their allegiance, or even forbidden to obey him; though many ecclesiastical writers in later times maintained that the excommunication of a prince ought not to have any influence on matters of political administration—a condition no less necessary than convenient, when the relations between princes and people had assumed a character very different from what they had been during the middle ages. In those times of ignorance and superstition, the Pope reigned supreme over the consciences of men; and if he thought fit to excommunicate a city, province, or country, the consequences were felt as a calamity of the heaviest kind. All religious services ceased; there was no regular burial, no ringing of the bells, &c., and relics and crucifixes lost their supposed efficacy. Of such excommunication or *interdicts* (as these are called when issued against a whole country), the first was that which Gregory V. pronounced against France, in the year 998, because King Robert refused to put away his lawful wife; and such were its consequences that the king was at last compelled to yield. But still more memorable is that issued against England by Innocent III., because King John refused to pay the tribute called Peter's-pence, and to acknowledge the Pope's right of nominating to the English bishoprics. In the end, however, John was obliged to yield, and received back his kingdom as a Papal fief. The excommunication of Henry VIII., too, is famous in history. No country has suffered so severely from interdicts as Germany, revolutions having frequently been the consequence of excommunications issued against the emperors. The latest instance of the excommunication of a sovereign, was that of Napoleon by Pius VII. in 1809. The Romanists use the phrase *fulminating an excommunication*, to signify the solemn denunciation after several admonitions; and the excommunication thus pronounced is called *anathema*. The ceremonies attending these fulminations are of a terrible character, and appear to have been first used in the eleventh century. The less excommunication only excluded from a participation in the sacraments and divine worship, and this is the sense in which the term is commonly used. This sentence is passed by judges ecclesiastical on such persons as are guilty of obstinacy or disobedience in not appearing upon a citation, or not submitting to penance or other injunctions of the court.

Excommunication, as a means of punishment, was introduced at an early period into England; and the English Church retains a form of excommunication in cases of adultery, heresy, simony, neglect of public worship, &c., but the use of it is now almost obsolete. Blackstone remarks that "heavy as the penalty of excommunication is, considered in a serious light, there are notwithstanding many obstinate or profligate men who would despise the *brutum fulmen* of mere ecclesiastical censures, especially when pronounced by a petty surrogate in the country, for railing or contumacious words, for non-payment of fees or costs, or other trivial causes. The common law, therefore, compassionately steps in to the aid of the ecclesiastical jurisdiction, and kindly lends a supporting hand to an otherwise tottering authority. This was done by the writ called *de excommunicato capiendo;* but by act 53d Geo. III., cap. 127, "no person who shall be pronounced or declared excommunicate (pursuant to the second clause of this statute) shall incur any civil penalty or incapacity in consequence of such excommunication, save such imprisonment, not exceeding six months, as the court pronouncing or declaring such person excommunicate shall direct." By the same act, a writ *de contumace capiendo*, which in effect is the same as the old writ *de excommunicato capiendo*, shall issue in all cases in ecclesiastical courts when a person shall refuse to appear, when cited by such court, or refuse to obey its decree, except in certain cases, as spiritual censures for offences of ecclesiastical cognizance.

EXCUBIÆ, in *Roman Antiquity*, denotes the watches in the camp, whether by day or night. The term *vigiliæ*, again, was restricted to the night-watches. *Excubiæ* and *vigiliæ* were also applied respectively to the individuals who performed such duty. The guards placed before the gates were properly called *stationes;* and those on the ramparts *custodiæ*. If a sentinel deserted his post he was punished with death. See ARMY, § *Roman Army*.

EXCUSATI, in *Ecclesiastical History*, a term used to denote slaves who, having fled to any church for sanctuary, were excused and pardoned by their masters; but the latter were obliged to take an oath to this effect before they could recover the fugitives; and if they broke it, they were punished and fined for perjury.

EXECRATION (*ex* and *sacer*), malediction; imprecation of evil. Among the ancient Jews, Greeks, Romans, and some other nations, it was customary to pronounce imprecations upon their enemies for the purpose of calling down the divine wrath, branding them with infamy, and exciting against them the passions of the multitude. By such means they also devoted their enemies to the ruin they considered them to deserve. Thus the Athenians proceeded against Philip of Macedon. They convened an assembly, in which it was decreed that all statues, inscriptions, or festivals in any way relating to him or his ancestors, should be destroyed, and every other possible reminiscence of him be profaned; and the priests, as often as they prayed for the success of the Athenian affairs, should pray for the ruin of Philip. It was also customary, after having destroyed cities in war, the revival of whose strength was dreaded, to pronounce execrations against those who should rebuild them. Execrations were sometimes pronounced upon cities before undertaking a siege, and before engaging with enemies in battle. Tacitus relates (*Annal.*, xiv. 29), that the priestesses of ancient Britain devoted their Roman invaders to destruction, with imprecations, ceremonies, and attitudes, which for a time overwhelmed the soldiers with terror.

EXECUTION, in a general sense, denotes performance or accomplishment. In law it signifies the putting the sentence of the law in force after the decision of a suit. This is done at common law by the following writs:—

1. By *capias ad satisfaciendum*, which is to imprison the body of the debtor until satisfaction be made for the debt or damages and costs. This writ does not lie against privileged persons, peers or members of parliament, nor can it be executed on a Sunday; and since the 7th and 8th Vict., cap. 96, sect. 58, it can only issue where the debt is above L.20. The debtor, when taken under this process, must remain in custody until he settles the debt or is otherwise lawfully discharged as an insolvent.

2. By *fieri facias*, which issues against the goods and chattels of the debtor, and lies against all persons without exception. There are certain restrictions and enactments as to the things liable to be seized, imposed by the several statutes of 8th Anne, cap. 14, 56th Geo. III., cap. 50, 1st and 2d Vict., cap. 110, sect. 12, and 14th and 15th Vict., cap. 25, sect. 2. Under these statutes, the landlord is first entitled to a year's rent; and the removal of hay, &c., is in certain cases excepted. This process may, since the 15th and 16th Vict., cap. 76, sect. 120, and rule 57 of Hilary Term 1853, issue within 14 days after trial unless the judge shall otherwise order. And under the 7th Geo. IV., cap. 46, sect. 13, the execution on any judgment against the public officer of any joint-stock bank may issue against any member for the time being, and if ineffectual, against any person who was a member at or before the time of the contract or judgment obtained, provided he has not ceased to be a member for three years.

3. By *levari facias*, which commands the sheriff to levy the debt on the land. This writ is now chiefly used against ecclesiastics, under which the bishop enters into the benefice and sequesters the same until the amount of the debt is levied.

4. By *elegit*, which was given by the 13th Edw. I., cap. 18, and has since been extended by the 1st and 2d Vict., cap. 110. Under this writ, the sheriff delivers execution of all the debtor's lands, tenements, and hereditaments; and it is of so high a nature, that after its issue the defendant's body cannot be taken, although after a *fieri facias* the body may be so taken.

In the *County Courts*, execution against the goods of a defendant is regulated by the 9th and 10th Vict., cap. 95, sect. 94; and that against the person by sect. 98.

In *Chancery*, this writ formerly issued to compel obedience to a decree or order, but it was abolished by the 10th general order of April 11, 1842, and mere service of the decree or order was substituted.

The last stage in *criminal* proceedings is also called execution—the completion of human punishment. This in all cases must be performed by the sheriff or his deputy within a convenient time, which before the 6th and 7th Will. IV., cap. 30, was on the day next but one after the sentence, unless it fell on a Sunday, and in that case on the Monday following. The universal mode in England is now that the prisoner be hanged by the neck till dead.

Improved legislation, together with the advance of civilisation, have done much to diminish the frequency of this extreme penalty of the law; and a strong public feeling now exists in favour of its total abolition. During the three years ending with 1820, the number of executions in England and Wales was 312; in the three years ending 1830 the number had decreased to 178; and in the three years ending 1840, to 62. The total number of executions in the United Kingdom in 1850 was only 16, of which *eight* took place in Ireland.

EXECUTIVE, in the theory of government, a term used in co-relation to *legislative* and *judicial*. The powers that enact laws are the legislative; those that apply them in particular cases are the judicial; those that carry them into effect and superintend their practical operation are the executive. In England, the executive is, by the constitution, supposed to be vested in the king and such inferior officers as he may appoint.

EXECUTOR, in *Law*, is one to whom is committed the duty of administering the moveable estate of a deceased person for the behoof of all concerned therein. In Scots law, executors are either *nominate*, *i.e.*, appointed by will, or *dative*, *i.e.*, appointed by the court. In English law, the term executor properly belongs only to the former of these, the latter being called administrators. Executors-dative and administrators are appointed when none have been nominated by will, or when those so nominated refuse to act. They differ from executors-nominate chiefly in the manner of their appointment; their duties are in general the same. The right to nomination as executors-dative or administrators is, generally speaking, in the order of interest in the moveable estate of the deceased. In Scots law, persons entitled to the estate by a general settlement have a right to be appointed before others; failing them, the next of kin are preferred; failing them, the widow; failing her, creditors,—and failing them, legatees. In English law, the widow or the next of kin or both of them may be appointed; failing them, creditors; and failing them, the Ordinary may appoint whomsoever he may think proper. In practice, however, it is usual when the executor refuses to act, to grant administration to the residuary legatee, that is, the person entitled by will to the remainder of the personal property after payment of the debts and legacies. An executor may refuse to act, but having once acted he cannot divest himself of the office or its responsibilities. He has to prove the will before the proper court, and to exhibit on oath an inventory of the whole moveable estate of the deceased on a stamp corresponding to the value of the estate; on which he obtains a title to act, called in England a *probate*, in Scotland a *confirmation*. Before obtaining this title he may take possession of the moveables, pay and receive debts, and do other acts in execution of the will, but cannot become a party in any suit either as pursuer or defen-

der The other duties of an executor are the burial of the deceased in a suitable manner, the collecting of his goods and chattels, and the recovery of such as are withheld, the payment of his just and lawful debts, deathbed and funeral expenses, and expenses of administration, and the disposal of the residue as by will or by law directed.

The office of executor is one of great trust and responsibility. As representative of the deceased, he has the same property in his goods as the principal had when living, and the same remedies to recover them. He is at the same time a trustee for behoof of the creditors, legatees, and next of kin of the deceased; and accordingly acts inferring fraud or negligence are treated with great severity. Executors-dative and administrators are required to find security for the faithful execution of their trust to an amount not exceeding the amount of the inventory. An executor is liable for the debts of the deceased only to the amount of the inventory, but if he intromit with the funds or moveables so as to lead to a suspicion of fraud, or so as to leave no means of ascertaining its extent, he is liable for all the debts of the deceased; and strangers intromitting in the same manner, incur the like liability. If he pay sums not due by the deceased, he will be personally liable for the amount to the persons interested, unless such are paid upon decrees. He is also held liable for any loss occasioned to the estate through negligence. The duties of an executor are of so varied and complicated a nature that any general directions must necessarily be imperfect and might tend to mislead; and therefore the only safe course in all cases of doubt, is to consult a legal adviser.

EXECUTRY, in *Scots Law*, the moveable estate falling to the executor. Under executry or moveables is comprehended everything that can be moved.

EXEDRA, or EXHEDRA (ἐξ and ἕδρα, *a seat*), in ancient architecture, a chamber furnished with seats, and opening into a portico, where the philosophers and rhetoricians lectured and held their disputations; or a vestibule in a private house, where people met to enjoy conversation. At Rome this term was applied to any hall or saloon for conversing or disputing in; especially the hall in Pompey's theatre, where the senate met.

In medieval architecture it is sometimes applied to the porch of a church, especially to the Galilee or western porch; and sometimes the apsis was similarly designated.

EXEGESIS, a Greek word signifying *explanation*, and used principally in theology to denote a discourse by way of exposition or comment upon a scriptural passage. It is nearly synonymous with *hermeneutics*. In theology, under the term *exegetics* are comprehended apologetic divinity, or the defence of revealed religion and of the Scriptures, the history of the sacred canon, interpretation, and sacred philology.

EXEGETES (from ἐξηγέομαι, *I explain*), a Greek word signifying an interpreter or guide. At Athens, the Eumolpidæ were designated *exegetæ*, as the expounders of the sacred laws, rites, and customs. The term was afterwards applied also to those who acted as guides (*ciceroni*) to strangers visiting the most remarkable places in Greece.

EXEGETICA, in *Algebra*, the art of finding, either in numbers or lines, the roots of the equation of a problem, according as it is either numerical or geometrical.

EXEGETICS, in *Theology*. See EXEGESIS.

EXERGUE (Fr. from ἐξ and ἔργον *work*), in *Numismatics*, the lower part of the face of a coin or medal, when separated from the principal subject by a horizontal line which serves as a base to the subject. It usually contains some cipher, device, date, &c., to which also the same term is applied.

EXETER, the capital of Devonshire, a city and county in itself, and a municipal and parliamentary borough on the Ex, 10 miles N.W. of its mouth in the English Channel, and 160 miles from London. It stands on the acclivity and summit of an eminence rising from the E. bank of the river, and is intersected by four principal streets, which meet in the centre. These are crossed in various directions by numerous smaller ones, which are generally narrow. The city, however, on the whole, is clean and well built. The best parts are beyond the line of the ancient walls, and the suburbs contain elegant streets and terraces and numerous detached villas. The surrounding country is very fertile, affording good corn, pasture, dairy, and fattening land, and abounding in fruit, especially apples, which yield plentifully the best cider. The beauty of the immediate neighbourhood, the contiguity of several favourite watering-places, and the cheapness of provisions, induce many families of easy but moderate circumstances to reside here. Exeter is supposed to have been a settlement of the Britons before the Roman conquest. By the Romans it was called *Isca Damnoniorum;* and many coins, small bronze statues, tesselated pavements, and other relics of that people, have been discovered. During the Saxon period it was for some time the capital of Wessex, and was noted for the number of its religious establishments. It has undergone several sieges. Exeter was formerly the emporium of the thinner kind of woollen goods, such as serges, druggets, and long ells, which were spun and woven in the neighbouring towns, and dyed and finished in the city. Hence they were shipped to Holland, Italy, and especially to Spain, and many were supplied to the East India Company; but the introduction of machinery, and the lower price of fuel in the north of England have now nearly destroyed those branches of trade, with the exception of that for the supply of India, which is still considerable. As Exeter is a kind of metropolis for Devon and Cornwall, it has a considerable internal trade, and is the channel by which these counties are supplied with many foreign commodities. By means of a ship canal vessels of 300 tons burden can come up to the town; those of greater burden remain at Topsham, three miles lower down; and those of the largest size lie at Exmouth, at the mouth of the river. On 31st December 1853 the vessels registered at the port were:—vessels under 50 tons 41, tonnage 1197; above 50 tons 146, tonnage 19,533. During 1853 the coasting vessels inwards were 598, tonnage 57,785; outwards 216, tonnage 9961: vessels in the colonial trade, inwards 98, tonnage 4392; outwards 25, tonnage 1415: in the foreign trade, inwards 128, tonnage 9645; outwards 40, tonnage 4372. Exeter contains two excellent market-houses. The market-days are Wednesday and Friday. There are few manufactures carried on in the city, the inhabitants being chiefly employed in the retail trade and in handicrafts. The city is governed by a mayor, 12 aldermen, and 36 councillors, and returns two members to parliament. Population (1851) of municipal borough 32,818; of parliamentary borough 40,688; registered electors 2501. The cathedral is a magnificent pile of building, and part of it of great antiquity, having probably been commenced soon after the see of Devon was transferred from Crediton to Exeter in 1049. It has, however, undergone numerous alterations and additions at different times. The W. front has a façade adorned with numerous statues in niches and a profusion of tracery, over which is a magnificent painted window. The interior is very striking, from its exquisite proportions and simple grandeur. A richly ornamented screen separates the nave from the choir, and is surmounted by a very large organ, the large pipes being nearly 23 feet in height and 4 feet in circumference. St Mary's chapel, the chapter-house, the bishop's throne of richly-carved black oak, and some of the ancient ornaments, deserve especial notice. The cathedral is surmounted by two massive Norman towers—the northern containing a clock curiously ornamented, and an immense bell weighing 12,500 lbs. (both gifts of Bishop Courtenay); and the southern having a

peal of eleven bells. The see includes nearly the whole of Devonshire and Cornwall. Exeter contains a great number of parish churches, besides several chapels of ease and Dissenting places of worship. Near the cathedral, on the south-east, is the bishop's palace, a venerable building. On an eminence N.E. of the city are the ruins of the Rougemont castle, formerly the residence of the West Saxon kings. The guild-hall in High Street contains several valuable portraits. Among the other public buildings may be mentioned the custom-house on the quay, theatre, cavalry and artillery barracks, bridewell, county jail, and city prison. A handsome stone bridge has been thrown over the river at an expense of L.20,000. Exeter contains also a subscription ball-room, a subscription library, a literary and scientific institution, with a valuable museum and library, a free grammar-school, with 18 exhibitions to either of the great universities, several national and charity schools, the Devon and Exeter hospital, deaf-mute institution, lunatic asylum, blind asylum, dispensary, eye infirmary, mechanics' institution, savings-bank, and several almshouses. It is connected with Bristol by railway.

EXFOLIATION, in *Surgery*, the separation of a piece of dead bone from the living part.

EXHALATION. See EVAPORATION.

EXHAUSTIONS, in *Mathematics*. The method of exhaustions is a way of comparing or estimating fixed magnitudes by means of variable magnitudes, which may be brought to approach or *exhaust* them more nearly than any assigned interval or remainder.

Thus, a regular polygon may be inscribed in a circle, and by repeatedly doubling the multitude of sides, or increasing it by other given laws, this variable figure may be made so to *exhaust* the circle as to leave a remainder less than any given area. And because similar polygons inscribed in different circles have always the duplicate ratio of the diameters, it has been perceived that the circles themselves must be as these exhaurient polygons, which Euclid proves strictly by the method of exhaustions.

A rectilineal figure may be inscribed in a segment of a parabola, so as to leave less of the parabola than any area assigned, and also to be nearer four-thirds of the greatest inscribed triangle than any given difference. Hence Archimedes proves, by the method of exhaustions, that the segment of the parabola exceeds the triangle by one-third of the same triangle.

The first lemma of Newton's *Principia* brings the method of exhaustions to general application. It is in these words:—

"Quantitates, ut et quantitatum rationes, quæ ad æqualitatem tempore quovis finito constanter tendunt, et ante finem temporis illius propius ad invicem accedunt quam pro data quavis differentia, fiunt ultimo æquales.

"Si negas; fiant ultimo inæquales, et sit earum ultima differentia D. Ergo nequeunt propius ad æqualitatem accedere quam pro data differentia D: contra hypothesin."

Many authors have not rightly understood this lemma: as Horsley in his note upon it; Hutton on Prime and Ultimate Ratios, in his *Dictionary;* and Woodhouse, *Principles of Analytical Calculation*, paragraph 105, where it is said to be "merely a definition," and, again, that "it gave a new signification to the term equality."

If our opinion be just, it gives no signification to the term equality which was not given by Euclid and Archimedes. The novelty is in giving to the word *ultimate*, or the adverb *ultimately*, an extension beyond what it ordinarily includes; as, in the technical language of the *Principia*, things are often said to be *ultimately* what, by their definition, they are incapable of becoming.

In this language, as explained by its author, an ultimate quantity, or that which a quantity ultimately becomes (*fit ultimo*), is what is otherwise called the *limit* of the quantity; that to which, repeating the words of this lemma, *tempore quovis finito constanter tendit, et ante finem temporis illius propius accedit quam pro data quavis differentia.* Thus, in the *scholium* after the eleventh lemma, our author says, *ad ultimas quantitatum evanescentium summas, id est, ad limites summarum.*

Few as are the words of the demonstration of this celebrated lemma, it must be concluded from them that it only concerns quantities of which it could be questioned whether they have a *fixed* difference. Applied to variables, it can therefore only compare them in some simultaneous magnitudes. Among simultaneous magnitudes, Newton, for the sake of brevity, includes limits; and, in fact, only these limits are here compared. Perhaps a slight change in the language may show more clearly the intention.

"Quantities, as also the ratios of quantities, which in any finite time soever constantly tend to equality, and before the end of that time approach nearer than any difference, have equal limits."

"If not, let their limits be unequal, and differ by D. Then the variables, in their approach, cannot come nearer than D, *contra hypothesin.*"

This may be too concise, but is fully made out in the following manner:—

Let X and Y be two quantities, continually approaching, and capable of being brought nearer than any difference within a finite time. Let A be the limit of X, and B the limit of Y; that is, let A and B be fixed quantities, to which X and Y, during their approach, may be brought nearer than any difference assignable. Then shall A and B be equal.

For, if not, let $A = B + D$. And at any time during the approach of X and Y, let m be the difference of X from its limit, and n the contemporary difference of Y from its limit. And,

I. Suppose the variables to approach by the decrease of the greater and the increase of the less towards their respective limits (like a circumscribed and inscribed polygon); or $X = A + m$, $Y = B - n$. Then $X - Y = A - B + m + n = D + m + n$, so that X and Y necessarily differ by more than D, *contra hypothesin.*

II. Suppose both variables to decrease towards their limits; or $X = A + m$ and $Y = B + n$. Then $X - Y = A - B + m - n = D + m - n$.

Now if n were greater than m, we might decrease Y by a part of n, which we will call y, greater than m itself, and still greater than its part (x), the contemporary decrement of X; and putting X′ and Y′ for the variables thus decreased, we should have $X' = X - x$, $Y = Y - y$, and thence $X - Y' = X - Y + (y - x)$; so that the difference of the variables would be augmented by bringing them nearer to their limits. Therefore n cannot be greater than m; consequently $D + m - n$ cannot be less than D, or the difference of X and Y cannot become less than D, *contra hypothesin.*

III. It only remains to examine the case where both increase towards their limits, or $X = A - m$, $Y = B - n$, and $X - Y = A - B + n - m = D + n - m$.

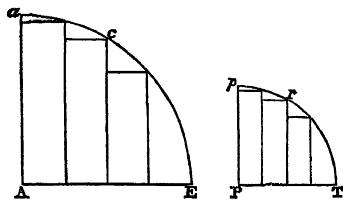
Here if m exceeded n, we might increase X by a quantity x greater than n, and still more exceeding y, the contemporary increment of Y, and putting X′ and Y′ to signify the variables thus increased, $X' - Y' = X + x = (Y + y)$, or $X' - Y' = X - Y + (x - y)$, so that the variables would again diverge. Therefore again $D + n - m$ cannot be less than D, or X and Y cannot differ by less than D, *contra hypothesin.*

If X, Y, A, B, D, m, n, x, y, represent *measures of ratios*, the proof includes the *quantitatum rationes.*

There results no absurdity from supposing the limits of two quantities which continually approach to have a difference D; but then the approaching quantities must always differ still more, contrary to one of the conditions.

Exhibition. By making n nothing in Case II. we make Y constant, and coincident in magnitude with B. The proposition obtained by the reasoning is, for this case, that whatever quantity A (suppose it a parabolic segment) may be an acknowledged limit of a variable X, if X can at the same time be proved to approach indefinitely to Y or B (suppose it a triangle equal to four-thirds of the greatest triangle in the parabolic segment), A is equal to B. This is to prove that limits of the same variable are equal, which is neither giving a new signification to equality, nor concluding an identical proposition, nor indeed one which an ancient geometer would have admitted without formal proof. We come to a similar conclusion by making m nothing in Case III.

It is true that, in the *Principia*, when a fixed quantity is proved to be a limit to a variable, and the variable then pronounced ultimately equal to the fixed quantity, the author or editors refer to the first lemma, when reference might as well be made to the definition of ultimate quantities there implied; only (what is the main thing) the demonstration of the lemma teaches how, by admitting the limit as a particular value of the variable, we cannot produce an error measured by any fixed quantity, while if an error were admitted at all it *must* be of fixed amount. Thus in Lemma IV. where the same multitude of rectangles is supposed to be inscribed in the two figures AacE, PprT, and when this multitude is indefinitely increased and consequently the breadth of the rectangles and the remainder of the areas indefinitely diminished, each rectangle in the one figure has, by hypothesis, the same ratio to a corresponding rectangle in the other; it is concluded that this is also the ratio of the whole figures. For the ratio of the area AacE to PprT may be viewed as compounded of AacE to the rectangles within itself, of these to the contemporary rectangles within PprT, and of these latter rectangles to PprT. But the first and last of the component ratios being *ultimately* of equality, the compound ratio is the constant ratio of the contemporary rectangles. For let L be the measure of the ratio of the inscribed rectangles, and let it be asserted that the compound ratio differs from L by a ratio whose measure is D. The first and last of the component ratios being ultimately of equality, their contemporary values may be made such that the measures (m and n) of the ratios by which the former exceeds equality and the latter falls below it, may be each less than D, and, *a fortiori*, their difference less than D. But L + $m - n$ is the true measure of the compound ratio; therefore L does not differ from the true measure by D.



Thus, by admitting ultimate values, no error is admitted. The method of exhaustions, which Newton's first lemma reduces to an enunciable proposition, only requires it to be allowed that fixed quantities either have a fixed difference or are equal. What is often called the principle of limits is to comprehend limits at once in the conclusion of a demonstration which does not apply to them. Newton's lemma serves to admit them through the method of exhaustions. According to the foregoing exposition, it is neither an identical proposition nor an arbitrary extension of the meaning of a term, though these inconsistent charges have both been brought against it. A and B are proved to be equal in the old signification of equality; and whilst it is said that X and Y are *ultimately* equal, X and Y are also ultimately A and B. (G. B. W.)

EXHIBITION (*exhibere* to exhibit, furnish, maintain, &c.), a showing or presenting to view; a display. In law, delivery of writings in proof of facts; a bill of discovery. In our old writers it is also used for an allowance of meat and drink, a pension or salary; and it is now applied to a benefaction settled for the maintenance of scholars in English universities, not depending on the foundation. In this sense the term is analogous to the Scottish *bursary*. Among physicians, exhibition is a standard and convenient term to express the administering of a medicine.

EXHIBITIONS *of Works of Fine Art.*—A collection of works of fine art arranged in some suitable place for public inspection is styled an exhibition. It is organized on a different principle from that of a national gallery or museum, for the works are not permanently conserved, but contributed for a limited period annually, new examples being provided for every successive exhibition.

Exhibitions are comparatively of modern institution. In former times artists were chiefly patronized by the church or the government, and the edifices in which their productions were placed were patent to the public; but now artists rely mainly on private patronage, and generally obtain the sanction of those for whom they execute works to exhibit them publicly for a limited period as specimens of their skill, or if executed for sale these exhibitions afford an opportunity of disposing of their works, while they themselves are improved in their art by the opportunity of comparing their own efforts with those of other artists.

The members of the Academy of the Fine Arts, founded at Rome in 1593, probably on particular occasions exhibited their works collectively to the public; but it was in France in 1737 that the members of the Royal Academy of Painting and Sculpture (founded 1648) first regularly instituted annual exhibitions. These were made biennial in 1745, and were from their commencement confined to works executed by members of the academy; but during the Revolution (by a decree in 1791) all artists, French or foreign, were allowed to participate in the exhibition, which in 1796 was again made annual.

The earliest attempt at an exhibition in England was in 1760; and the efforts of the artists were at length united in the Royal Academy's exhibitions, the first of which was opened in 1769. Since then they have been continued with increasing energy. In 1760 the number of works exhibited was 130, contributed by 69 artists; in 1855 there were 1558 works, contributed by 918 exhibitors. The annual revenue of the academy arises from a fee of one shilling from each visitor, and now exceeds L.8000.

The Royal Scottish Academy's exhibition is the second in importance in the United Kingdom. Though according to its present constitution it only dates from 1826, those who instituted it had previously organized exhibitions in Edinburgh, which had been annually continued, with some few interruptions, since 1808. At the first exhibition, 178 works were sent in by 27 contributors; at the exhibition in 1855 789 works were contributed by 287 exhibitors. The annual revenue exceeds L.2000. Exhibitions are annually opened in Dublin by the Royal Hibernian Academy. These are the only fine-art corporations in this country aided by government, the two first-mentioned being accommodated in public galleries, and the last receiving an annual money grant. Besides the above mentioned the following societies in London have also exhibitions, namely, the British Institution, founded in 1806; the Society of British Artists, in 1824; the National Institution, in 1850; the Society of Painters in Water Colours, in 1805; and the New Society of Painters in Water Colours, in 1835. There are also annual exhibitions in Manchester, Liverpool, Glasgow, Birmingham, Cork, Newcastle, &c. But with the exception of those in London and the Royal Scottish and Hibernian Academies, they are mainly composed of works collected all over the kingdom, but principally in London.

EXHIBITION OF 1851.—The Great Exhibition of Works of Industry of all Nations, held in the British metropolis,

was publicly announced in October 1849. Prince Albert, as president of the Society of Arts, offered himself to the public as their leader in the undertaking; and her Majesty's proclamation appointing a commission to promote the project was issued January 3, 1850. The amount of public subscriptions to the Crystal Palace was L.67,399, 3s. 10d. After much discussion relative to the site proposed, a vast structure was erected on the south side of Hyde Park, from a design of Mr (afterwards Sir Joseph) Paxton. This building (usually called the Crystal Palace from the material of which it was chiefly composed) resembled, upon a great scale, the Victoria Regia plant-house erected at Chatsworth, after Mr Paxton's own design. The contract with Messrs Fox and Henderson was for L.79,800—a sum afterwards somewhat increased by additions to the plan; or for L.150,000 if the building were permanently retained. The exhibition was opened by her Majesty in state, May 1, 1851; and it remained open to the public till 11th October—shortly after which time the Crystal Palace was taken down.

This gigantic structure occupied an area of 21 acres, and was composed entirely of large sheets of glass set in a framework of iron, except near the ground, where it was boarded. Its length was 1851 feet (a number corresponding to the year of the exhibition); and its width in the broadest part 456 feet: the transept, intersecting the building at right angles in the middle, was 408 feet long, 108 high, and 72 wide. The entire structure consisted of three tiers of elevation, the central portion being 64 feet high, the adjacent side portions 44 feet, and the outer sides 24 feet high. The materials employed were as follows:—896,000 superficial feet of glass weighing 400 tons; wrought-iron 550 tons; cast-iron 3500 tons; wood, including flooring, 600,000 cubic feet; nearly 2300 cast-iron girders, and 358 wrought-iron trusses for supporting the roof and the galleries (which extended nearly a mile in length); 30 miles of gutters; 202 miles of sash-bars, and 3330 cast-iron columns. The number of exhibitors was about 17,000; of prize-medals awarded, 2918; of council medals, 170. The greatest number of visitors in one week was in that ending 11th October, when the number of persons paying at the doors was 478,773. The total amount of entrance fees during the season was L.424,418, 15s.

The Great Exhibition of 1851 was altogether novel in principle, and unparalleled in magnitude and magnificence; comprehending under one roof, in almost endless variety, specimens of the industrial productions, not only of Great Britain, but of the European states generally, together with those of nearly every part of the habitable globe. An account of these, as well as of the peculiar mode of construction of the Crystal Palace, may be found in the official descriptive and illustrated catalogues and reports of the juries.

Our limits preclude our entering into the history of national industrial exhibitions, or to make more than a passing reference to the various local exhibitions of works of industry which have taken place from time to time in the United Kingdom, such as those at Cork, Sheffield, Plymouth, and Salisbury in 1852, Dublin in 1853, and in Birmingham in 1849. Similar exhibitions were organized in Belgium in 1830, in the United States in 1853, at Munich in 1854, and especially in France in 1798, 1801, 1802, 1806, 1819, 1844, and on a large scale in 1855. This last is constituted on an entirely different basis from the English Exhibition of 1851; being set on foot by the capital of a commercial company formed for the purpose, and on the prospect of remunerative profits; but the state also takes a distinct and positive share in the risks of the enterprise, as it does with railways and other works of public utility. A certain percentage to the holders of stock is guaranteed by the government; and in right thereof an imperial commission is appointed which exercises supreme control. By this arrangement the proprietors are to receive whatever surplus may remain after all expenses are paid; whereas the L.170,000 derived from the prices of admission to the London Exhibition stands over as a public trust fund, under royal charter, to be applied to objects in harmony with those for which the exhibition was held.

The French Exhibition is not contained under one roof, nor of the several buildings are all intended to be of a temporary character. The buildings, in the aggregate, will probably include greater area than the Crystal Palace in Hyde Park. The main building is the Palais de l'Industrie, a permanent edifice of rectangular form and with considerable pretensions to architectural effect. In this will be exhibited all the higher productions of manufacturing industry. There is also the "Annexe," a shed 4000 feet long, parallel to the Seine, for the exhibition of machinery and raw produce. According to the plan, these two structures are connected by a gallery running across the Champs Elysées, and having in its centre a fine circular space, which is appropriated to the productions of Sèvres and the other national establishments; and in addition there is an extra shed for the exhibition of carriages and other articles of great bulk.

For an account of the Crystal Palace at Sydenham, see SYDENHAM. Other exhibitions of works of art generally will be found under the heads of the places where they are held; as London, Edinburgh, Paris, &c.

EXIGENT, or EXIGI FACIAS, in law, a writ that issues where the defendant in an action is not to be found, or after a return of *non est inventus* on former writs. It requires the sheriff to cause the defendant to be called or *exacted* in five successive county courts to render himself; and if he does not appear, a judgment of outlawry is pronounced against him.

EXILE, in *Roman Antiquity*, a form of punishment, of which there were various degrees. Offences which came under the category of "capitalia" were punished either with death or with banishment; and this banishment consisted in the *aquæ et ignis interdictio*, which involved the loss of citizenship to the criminal. Other kinds of banishment were properly called *relegatio*, which word could not be used as a term of personal reproach in the same manner with exsul. Thus Ovid declares himself to have been merely a relegatus, alleging that Augustus

Nil nisi me patriis jussit abire focis.

This distinction between relegatio and exsilium subsisted also in the times of the republic. During that era no Roman citizen could be deprived of his citizenship by a special statute unless he were previously condemned in a judicium. Even such as were convicted of capital offences did not lose their citizenship at Rome until they were admitted citizens of some other state; and this was effected not by the ademptio civitatis, but by the interdictio aquæ et ignis. Any citizen, however, who voluntarily exchanged his Roman citizenship for that of some other state, ceased by that very act to be a Roman citizen, as it was one of the fundamental principles of the Roman law that a man could not simultaneously be a citizen of two states. (See CITIZEN; OSTRACISM, &c.)

EXMOUTH, a market-town and watering place of England, county of Devon, at the mouth of the Ex, ten miles S.S.E. of Exeter. Pop. (1851) 5123. Exmouth was early a place of importance, and in 1347 contributed ten vessels to the fleet sent to attack Calais. It was the first watering-place on the coast of Devon, and is frequented not only for bathing, but also as a winter residence by those suffering under pulmonary diseases, as it is celebrated for the mildness of its climate, and is well sheltered from the N.E. and S.E. winds by some high hills which rise almost close behind it. The rides and walks in the neighbourhood are remarkably beautiful, and the Beacon hill commands one of the finest views in the south of England. It possesses assembly rooms, baths, libraries, and other essentials of a fashion able watering-place.

EXODIUM, in the ancient Greek drama, the conclusion of a tragedy; or, more strictly, that portion of the play in which the catastrophe is indicated and the plot begins to be unravelled.

Among the Romans the name of *exodia* was given to pieces of a burlesque or comic description acted after other plays, or as interludes; or perhaps the *exodia* were sometimes travesties on the subject of the play itself. These pieces were in verse, and were inserted in other plays, but chiefly in the *Atellanæ*. Their real character has not been very precisely ascertained; but it would appear that although distinct from the *Atellanæ* they were for the most part intimately connected with them. Under the emperors, *exodia*, or ludicrous pieces interlarded with much ribaldry and buffoonery, were performed by young and well-born Romans, who came forward at the conclusion of the tragedy or other play, after the professional actors and musicians had left the stage.

EXODUS (ἐξ and ὁδός a path or way), departure from a place. The second book in the Old Testament is thus designated, as containing a narrative of the departure of the Israelites out of Egypt under the conduct of Moses. See PENTATEUCH.

EXOGENOUS, a term applied in botany to plants in which growth takes place by increase from without; as distinguished from *endogenous* plants, or those of which the wood is formed by successive augmentations from the inside. See BOTANY.

EXORCISM, the act of expelling evil spirits from persons or places by means of certain adjurations and ceremonies. The belief in demoniacal possessions, which may be traced in almost every nation, has always been attended by the professed ability, on the part of some individuals, to release the unhappy victims from their calamity. In Greece, men of no less distinction than Epicurus and Æschines were sons of women who lived by this art; and both were bitterly reproached, the one by the Stoics, and the other by Demosthenes (*De Cor.*), for having assisted their parents in these practices. This power was in some instances considered as a divine gift; in others it was thought to be acquired by investigations into the nature of demons and the qualities of natural productions, as herbs, stones, &c., and by the use of certain forms of adjurations and ceremonies. Indeed the various forms of exorcism, alluded to in authors of all nations, are innumerable. The power of expelling demons Josephus places among the endowments of Solomon, and relates that he *left behind him* the manner of using exorcisms by which they drive away demons. (For the pretended fragments of these books see Fabric. *Cod. Pseud. Vet. Test.*, p. 1054.) He relates that he had seen a man named Eleazar releasing people that were demoniacal, in the presence of Vespasian, his sons, captains, and soldiers, by means of a certain root set in a ring; on the application of which to the nose of the patient, the devil was expelled through his nostrils. (See *Antiq.* viii. 2, § 5; and *De Bell. Jud.* vii. 6, § 3.) The profession of exorcist was not uncommon among the Jews; and the epithet applied to such persons (περιερχομένων, Vulg. *de circumeuntibus Judæis*) would indicate that they were travelling mountebanks, who, having perhaps some knowledge of medicine, pretended also to magical skill. The subject of demoniacal possession is treated at length under the head DÆMONIAC.

The practice of exorcism still makes a part of the superstitions of some churches. In the religious system of the Church of Rome, (the rituals of which forbid the exorcising of any person without the bishop's leave,) the ceremony is performed at the lower end of the church, towards the door. The exorcist first signs the possessed person with the figure of the cross, desires him to kneel, and sprinkles him with holy water; then follow the litanies, psalms, and prayer; after which the exorcist asks the devil his name, and abjures him by the holy mysteries of the Christian religion not to afflict the person possessed any more. Then, laying his right hand on the dæmoniac's head, he repeats the form of exorcism as follows: "I exorcise thee, unclean spirit, in the name of Jesus Christ; tremble, O Satan, thou enemy of the faith, thou foe of mankind, who hast brought death into the world, who hast deprived men of life, and hast rebelled against justice; thou seducer of mankind, thou root of evil, thou source of avarice, discord, and envy." Houses and other places supposed to be haunted by unclean spirits are likewise to be exorcised with ceremonies very similar.

EXORCISTS, in *Ecclesiastical History*, an order of men in the ancient church, whose employment it was to exorcise or cast out devils. They owed their origin to the doctrine of the neo-Platonists, adopted by the Christians, that vicious men are impelled to sin less by their natural depravity than by the suggestions of some evil spirit lodged within them.

EXORDIUM, in *Rhetoric*, the preamble or introduction to a discourse, which serves to prepare the audience for the main subject. It is either formal and deliberate, or vehement and abrupt, according to the nature of the subject.

EXOSMOSE, and ENDOSMOSE, are relative terms derived from the Greek ὠσμός signifying *impulsion*, and applied to the attraction of one gas, vapour, or liquid for another of less density, operating through a vegetable or animal membrane, or other porous medium. When two fluids of different densities are separated from each other by such medium, the denser will attract the lighter fluid. When the transmission thus effected is from within outwards, it is termed *exosmose;* and when the action is in the contrary direction, it is termed *endosmose.* This subject is treated in more detail under BOTANY, vol. v., p. 68.

EXOTERIC, and ESOTERIC, are terms denoting *external* and *internal*, and applied to the double doctrine of the ancient philosophers, particularly those of the Peripatetic school. The one was public or *exoteric;* the other secret or *esoteric.* The first was that which they openly professed and taught to the world; the latter was confined to a small number of chosen disciples. This method was derived originally from the Egyptians, who, according to the united testimony of Herodotus, Diodorus Siculus, Strabo, Plutarch, and others, had a twofold philosophy; the one secret and sacred, the other public and common. The same practice also obtained amongst the Persian Magi, the Druids of the Gauls, and the Brahmins of India. The Egyptian priests, with whom it originated, sustained the character of judges and magistrates, and probably introduced this distinction with a view to the public welfare, and to serve the purposes of legislation and government. As Clemens Alexandrinus informs us, they communicated their mysteries principally to those who were concerned in the administration of the state; and Plutarch confirms this declaration. Others, however, have supposed that they invented the fables of their gods and heroes, and the external ceremonies of their religion, to disguise and conceal natural and moral truths; but whatever may have been the motive of their practice, it was certainly applied to political purposes. See ESOTERIC.

EXOTIC (ἔξωθεν *from without* or *abroad*), foreign; pertaining to or produced in a foreign country; extraneous. The term is used chiefly of plants, particularly those brought from tropical countries. It is also applied to words of foreign origin.

EXPANSION, in *Physics*, denotes the enlargement or increase of bulk in bodies, chiefly by means of heat. This is one of the most general effects of that subtile principle, and common to all bodies whatever, whether solid or fluid. In some few cases, indeed, bodies seem to expand as they grow cold, as water in the act of freezing; but this is found to be owing to a new arrangement of the particles, or to crystallization, and is not at all a regular and gradual ex-

pansion like that of metals or any other solid or fluid substance by means of heat. In certain metals also, an expansion takes place when they pass from a fluid to a solid state; but this too is not to be accounted any proper effect of cold, but of the arrangement of the parts of the metal in a peculiar manner; and it is therefore to be ascribed to a kind of crystallization.

EXPECTATION, in the doctrine of chances, is applied to any contingent event, and is capable of being reduced to the rules of computation. Thus a sum of money in expectation when a particular event happens, has a determinate value before that event arrives; so that if a person is to receive any sum, say L.10, when an event takes place which has an equal probability of happening and failing, the value of the expectation is half that sum, or L.5; and in all cases the expectation of obtaining any sum is estimated by multiplying the value of the sum expected by the fraction which represents the probability of obtaining it. The expectation of a person who has three chances in five of obtaining L.100, is equal to $\frac{3}{5} \times 100$, or L.60, and the probability of obtaining L.100 in this case is equal to $\frac{60}{100} = \frac{3}{5}$. See PROBABILITIES.

EXPECTATION of Life signifies that share or number of the years of human life which a person of any given age may expect to enjoy upon an equality of chances. See ANNUITIES.

EXPERIMENTAL PHILOSOPHY. See PHILOSOPHY, PHYSICS, MECHANICS, &c.

EXPERIMENTUM CRUCIS, a *crucial* experiment, or one which is decisive, confirming or disproving at once the question at issue. An experiment is thus termed either because it resembles a cross or direction-post to point out the true course of discovery, or rather as being a kind of torture by means of which the nature of the thing experimented on is as it were extorted by force.

EXPIATION, FEAST OF (called by our translators the Day of Atonement), a Jewish festival held on the tenth day of Tishri, or the seventh month of the Jewish year; on which day the high priest entered into the holy place, and having confessed his sins, made an atonement for all the people.

EXPLOSION, a sudden and violent expansion of an aerial or other elastic fluid, by which it instantly throws off any obstacle that happens to be in the way, sometimes with great force, and in such a manner as to produce destructive effects upon adjacent objects.

With regard to solids, explosion differs from expansion, which is a continuous power, acting uniformly for some time; whereas the former is sudden, and only of momentary duration. The expansions of solid substances do not terminate in violent explosions, on account of their slowness, and the small space through which the metal, or other expanding substance, moves; though their strength may be equally great with that of the most active aerial fluids. Thus we find that though wedges of wood when moistened will cleave solid blocks of stone, they never throw them to any distance, as is the case with gunpowder. On the other hand, it is seldom that the expansion of any elastic fluid bursts a solid substance without projecting the fragments of it to a considerable distance. The reasons of this are, first, the immense velocity with which the aerial fluids expand, when affected by a considerable degree of heat; and, secondly, their celerity in acquiring heat and being affected by it, which is much superior to that of solid substances. Thus air, heated as much as iron when brought to a white heat, is expanded to four times its bulk; but the metal itself will not be expanded the five-hundredth part of its bulk.

In the case of gunpowder, the velocity with which the flame moves is calculated by Robins (*Treatise upon Gunnery*) to be no less than 7000 feet in a second, or little less than 79 miles in a minute. Hence the impulse of the fluid is inconceivably great, and the obstacles on which it strikes are hurried off with vast velocity, though much less than that just mentioned; for a cannon ball, with the greatest charge of powder that can be conveniently given, does not move at a greater rate than 2400 feet in a second, or little more than 27 miles in a minute. The velocity of the ball, again, is promoted by the sudden propagation of the heat through the whole body of air, as soon as it is extricated from the materials of which the gunpowder is made; so that it is enabled to strike all at once, and thus greatly to augment the momentum of the ball. That this contributes much to the force of the explosion is evident from what happens when powder is wetted or mixed with any substance, which prevents its taking fire all at once. In this case the force of the explosion, even when the same quantity of powder is made use of, cannot be compared to that of dry powder.

Upon these principles we may conclude that the force of an explosion depends, first, on the quantity of elastic fluid to be expanded; secondly, on the velocity it acquires by a certain degree of heat; and, thirdly, on the celerity with which the degree of heat affects the whole of the expansive fluid. These three take place in the greatest perfection where the electric fluid is concerned, as in cases of lightning. In violent lightning, where the electric fluid collects itself into balls, the strength of the explosion is proportional to the quantity. The violent effects of lightning when it strikes buildings, trees, or even the most solid rocks, is well known; and in some cases, where the quantity of electricity is still greater than in any flash of lightning, still more tremendous consequences ensue. Dr Priestley gives an instance of a large fire-ball, or quantity of electric matter, rolling on the surface of the sea, which, after rising up to the topmast of a ship of war, burst with such violence, that the explosion resembled the discharge of hundreds of cannon fired at once. Great damage was done by it; but there is not the least doubt that most of its force was spent on the air, or carried down to the sea by the mast and iron-work of the ship. Considering, indeed, that in all cases a great part of the force of electrical explosions is dissipated in this manner, it is impossible to measure it by any method applicable to the mensuration of other forces.

Next in strength to the aerial vapours are those of aqueous and other liquids. The most remarkable effects of these are observed in steam-engines; but there is one particular case from which it has been inferred that aqueous steam is incomparably stronger than the flame of gunpowder. This is when water is thrown upon molten copper; for here the explosion is so strong as almost to exceed imagination; and terrible accidents have been known to happen from such a slight cause as one of the workmen spitting in the furnace where copper was being melted.

It may now be asked, why such explosions do not take place when water is thrown upon the surface of any other metal, for instance iron, when in a state of fusion? In answer to this it may be observed, that water is decomposed by being applied to red-hot iron in the form of steam, and one of its elements enters into combination with the iron. It may be observed, that in all cases where a very hot body is thrown upon a small quantity of water in the liquid state, an explosion will follow. Here the water is confined, and suddenly rarefied into steam, which cannot escape without throwing off the body which confines it. Examples of this kind frequently occur where masons or other mechanics are employed in fastening cramps of iron into stones; if there happen to be a little water in the hole into which the liquid lead is poured, the latter will fly out in such a manner as sometimes to occasion serious accidents. Occurrences of this kind have sometimes happened in founderies, when molten metal has been poured into wet moulds. In these cases, the sudden expansion of the aqueous steam throws

out the metal with great violence; and if any decomposition take place at the same time, so as to convert the aqueous into an aerial vapour, the explosion will be still greater.

A similar explosion takes place on pouring cold water into boiling or burning oil or tallow. The same effect follows whether we pour the oil on the water or the water on the oil. In the former case the water, which lies at the bottom, is rarefied into steam, and explodes; in the latter, it sinks down through the oil by its superior specific gravity, and explodes as it passes along. In either case, however, the quantity of aqueous fluid must be but small in proportion to that of the oil; a very great quantity would put out the flame, or destroy the heat, in whatever way it might be applied.

The effects of explosions, when violent, are felt at a considerable distance, by reason of the concussions they give to the atmosphere; for all of them act upon the atmospherical fluid with the same force which they exert upon terrestrial substances subjected to their action. Sir William Hamilton relates, that in consequence of the explosions of Vesuvius in 1767, the doors and windows of the houses at Naples flew open if unbolted, and one door was burst open though it had been locked. The same effect has been observed on the explosion of powder-magazines.

EXPONENT, or INDEX, in *Algebra*. See ALGEBRA, vol. ii., p. 491.

EXPONENT of the ratio, in arithmetic, is the quotient arising when the antecedent is divided by the consequent of the ratio. Thus 4 is the exponent of the ratio of 20 to 5; for $\frac{20}{5} = 4$.

EXPONENTIAL Calculus, the method of differencing, or finding the fluxions of exponential quantities, and of summing up those differences, or finding their fluents.

EXPONENTIAL Curve is that the nature of which is defined or expressed by an exponential equation; as the curve denoted by $a^x = y$, or by $x^x = y$.

EXPONENTIAL Equation is one in which is contained an exponential quantity; as the equation $a^x = b$, or $x^x = ab$, &c.

EXPONENTIAL Quantity is that the power of which is a variable quantity; as the expression a^x, or x^y. Exponential quantities are of several degrees and orders, according to the number of exponents or powers.

EXPOSING OF CHILDREN. This was a common practice among the Greeks, Romans, and other ancient nations. But from this charge must be excepted the Thebans, who had an express law by which it was made capital to expose children, and at the same time ordained that such as were not in a condition to educate their offspring should take them to the magistrates, that they might be brought up at the public expense. Among the other Greeks, when a child was born, it was laid on the ground; and if the father designed to educate it, he immediately took it up; but if he forbore to do so, the child was carried away and exposed. The Lacedæmonians indeed had a different custom: with them all new-born children were brought before certain persons, considered as among the wisest in their own tribes, by whom the infants were carefully examined; and if the latter were found strong and well formed, orders were given for their education, with a certain proportion of land for their maintenance; but if weakly or deformed, they were cast into a deep cavern in the earth, near Mount Taygetus, as it was thought neither for the good of the infants themselves nor for the public interest that defective children should be reared. Many children were exposed only because their parents were not in a condition to educate them; and it was the unhappy fate of daughters especially to be thus treated, as their education and settlement in life involved a greater expense than those of sons. The parents frequently tied jewels and rings to the children they exposed or any other thing by which they might afterwards discover them, if they should survive; or to encourage those that might find them to nourish and educate them; or, if found dead, to give them human burial. It was usual to expose children in such places as were most frequented, in order that they might be found and compassionated by persons who were in circumstances to defray the expense of their education. As foundlings became the property of those who brought them up, instances were not wanting of great cruelties exercised towards these unfortunate individuals; such as, for instance, mutilating their persons and exhibiting them in the streets, in order to derive an infamous livelihood from the alms bestowed on them by compassionate passengers. By a law passed at Rome A.D. 374, the exposure of children was made a punishable offence; but it was not till the year 530 that their slavery was abolished, when Justinian published an edict to that effect.

EX POST FACTO, a law phrase used to denote something made to apply to a thing already done. Thus, for example, a law is said to be made *ex post facto* when it renders an offence punishable in a manner in which it was not punishable at the time it was committed.

EXPRESSED OILS, are such as are obtained from bodies by pressure only. See OILS.

EXTENT, in *Law*, is used in a double sense, denoting either a writ of execution (called also an *extendi facias*) directed to the sheriff against the person, lands, and goods, or the lands only, of a debtor; or the act of the sheriff or officer upon this writ. These writs are of two kinds, to both of which the sovereign is by ancient prerogative entitled, for the purpose of obtaining satisfaction of debts due or assigned to the crown. The writ of *extent in chief* is a proceeding by the sovereign for the recovery of his own debt, and in which he is the real plaintiff. The writ of *extent in aid* is also sued out at the instance and for the benefit of the crown against the debtor of a crown debtor. In this last proceeding the sovereign is only the nominal plaintiff.

EXTRACT, in *Pharmacy*, a preparation of vegetable principles obtained by digesting vegetable substances in water or in alcohol, and evaporating them to a pasty or solid consistence; or by boiling down the expressed juices of fresh plants. According to the mode of preparation, they are termed either aqueous or spirituous extracts.

The name *extractive principle*, or *extractive*, is given by chemists to a peculiar principle which is supposed to form the basis of all vegetable extracts.

EXTRACT OF LEAD, the name given to the impure acetate of lead obtained by boiling litharge in vinegar. It is commonly known as *Goulard's extract*.

EXTRACTION OF ROOTS, in *Algebra* and *Arithmetic*, the method of finding the roots of given numbers or quantities. See ALGEBRA and ARITHMETIC.

EXTRAORDINARII, in the ancient Roman army, a select body of men consisting of the third part of the foreign cavalry and a fifth of the infantry. These were carefully separated from the other forces borrowed from the confederate states, in order to prevent any treacherous coalition between them. From among the *extraordinarii* a more choice body of men were drawn, under the name of *ablecti*.

EXTRAVAGANTES, a name given to certain decretal epistles, or constitutions of the popes, which were published from the Clementines, but were not at first digested or arranged with the other papal constitutions. Hence the name which they continued to retain, even after their insertion in the body of the canon law. See CANON LAW, vol. vi., p. 190.

EXTRAVASATION (*extra* beyond, and *vas* a vessel), in *Medicine*, the escape of blood, or other fluid, from its natural receptacle into a neighbouring part of the body. The fluid thus thrown out is said to be *extravasated*.

EXTREME, in *Logic*. The *extremes*, or extreme terms of a syllogism, are the predicate and subject. They are called *extremes* from their relation to another term, which is a medium or mean between them. Thus, in the syllogism, "Man is an animal; Peter is a man; therefore Peter is an animal; the word *animal* is the greater extreme, *Peter* the less extreme, and *man* the medium.

Extreme and mean proportion, in *Geometry*, is when a line is so divided, that the whole line is to the greater segment as that segment is to the other; or, as it is expressed by Euclid, when the line is so divided that the rectangle under the whole line and the lesser segment, is equal to the square of the greater segment.

EXTREME UNCTION has been since the twelfth century one of the seven sacraments of the Roman Catholic Church. The ceremony is performed as follows:—When a person is supposed to be at the point of death, his eyes, ears, nostrils, mouth, and hands are successively anointed with the sacred oil by the priest. At each anointing the priest says: "By this holy unction, and through His great mercy, Almighty God forgive thee whatever sins thou hast committed by 'sight,' 'smell,' 'hearing,' 'touch,'" &c. At the same time the priest has the power of absolving the dying person from all sins, even from those which in the seventh chapter of the decree on penance are reserved to the decision of the Supreme Pontiff. The oil used in extreme unction is supposed to represent the grace of God poured down into the soul, and the prayer offered up at the time of anointing to express the remission of sins thereby granted to the sick person. The Council of Trent has decreed extreme unction to be a sacrament, and declares that, "Whoever shall affirm that extreme unction is not truly and properly a sacrament, instituted by Christ our Lord, and published by the blessed apostle James, but only a ceremony received from the fathers, or a human invention, let him be accursed." And it denounces a similar anathema against all who "shall affirm that the sacred unction of the sick does not confer grace, nor forgive sin, nor relieve the sick, but that its power has ceased, as if the gift of healing existed only in past ages" (Sess. xiv. Can. I. *et seq.*) As this unction has, according to the tenets of the Romish Church, sacramental efficacy, purifying the dying person from his sins, and communicating to him divine forgiveness, it can only be administered by a bishop or priest, and is not to be given to infants or to excommunicated persons, or to those who die impenitent, or in the actual commission of mortal sin. Roman Catholics found their opinion of the efficacy of extreme unction on the custom of the apostles, who "anointed with oil many that were sick, and healed them," and on the exhortation of the apostle James (v. 14): "Is any sick among you? let him call for the elders of the church, and let them pray over him, anointing him with oil in the name of the Lord." On the other hand, Protestants deny the sacramental significance and efficacy of this ceremony, because nothing is known of a formal establishment of it by Christ himself. They allege that "extreme unction," from its very nature, is to be administered only in the immediate prospect of death, and when the patient is past all hope of recovery; whereas the anointing practised by the apostles and other early ministers of religion was with a view not to the death but the recovery of the sick person —not that he might be prepared to die, but that he might be restored to health: "and the prayer of faith shall save the sick, and the Lord shall raise him up" (Jas. v. 15). The Orientals are strongly persuaded of the sanative properties of oil; and it was under this impression that the Jews anointed the sick and applied oil to wounds (Isa. i. 6, Mark vi. 13; Luke x. 34). Anointing was therefore employed as a cure for various disorders, as well as for the purpose of promoting the general health of the body. This custom still prevails in the East. The Jews in Mocha assured Mr Forskal that the Mohammedans as well as the Jews in Sana, when they were sick, were accustomed to anoint the body with oil; and Niebuhr states that, "in Yemen the anointing of the body is believed to strengthen and protect it from the heat of the sun, by which the inhabitants of this province, as they wear but little clothing, are very liable to suffer. Oil, by closing up the pores of the skin, is supposed to prevent that too copious transpiration which enfeebles the frame; when therefore the intense heat comes on, the Arabs always anoint their bodies with oil." In the Greek Church unction is administered not only to dying persons, but generally in diseases of all kinds, as tending to promote the restoration of health, as well as the forgiveness of sins. (J. T—R.)

EXUVIÆ (Latin), a term applied in natural history to the cast skins, shells, or coverings of animals; as the skins of serpents and caterpillars, the shells of lobsters, &c. It is also applied to fossil spoils, or remains of animals.

EY, the pure Islandic or Scandinavian for *island;* from which comes *eyet*, or *eyght*, an *islet*.

EYE. See Anatomy, iii. 43; and Optics.

EYE, a municipal and parliamentary borough and market-town of England, county of Suffolk, 20 miles N. of Ipswich. It is governed by four aldermen and twelve councillors, and returns one member to parliament. Pop. (1851) of municipal borough, 2587; of parliamentary borough, 7531. Registered electors, 356. Eye is situated in a low fertile tract of country, and is nearly surrounded by a small stream, an affluent of the Waveney. The streets are narrow, irregular, and unpaved, while the white-washed houses and thatched roofs give Eye the appearance of a large agricultural village. The church is a spacious cruciform edifice, with a fine embattled tower. The free grammar-school has two exhibitions to Cambridge University. The guild-hall is a handsome modern building. There were formerly a castle and a small Benedictine priory at Eye;—the former has disappeared, but of the latter some ruins are still to be seen to the east of the town. Market-days, Tuesday and Saturday. Eye received its first charter from King John; and previous to the passing of the Reform Act returned two members to parliament. The inhabitants are chiefly employed in agriculture.

EYEMOUTH, a small seaport and market town of Scotland, county of Berwick, situated at the mouth of the Eye, 7 miles north of Berwick. It is a place of considerable antiquity, and had a fort of great strength, which, however, has been destroyed. Being the Scottish harbour nearest to England, it was a place of importance in the wars between the two countries. In later times it was for many years famous for smuggling, but that illicit traffic has been long suppressed. The harbour has been much improved by the erection of a breakwater, and vessels may now enter and depart at all times of the tide. Eyemouth has a weekly grain market, and extensive granaries have been erected near the pier. Pop. of parish (1851) 1488, many of whom are engaged in the fisheries.

EYRE (? *iter* a journey), in *Law*, signifies the court of justices itinerant. Hence the expression, justices in eyre.

EZEKIEL, *i.e.*, [*whom*] *God will strengthen*, or *God will prevail*, one of the greater prophets, whose writings, both in the Hebrew and Alexandrian canons, are placed next to those of Jeremiah. He was the son of Busi the priest, and, according to tradition, was a native of Sarera. Of his early history we have no authentic information. We first find him in the country of Mesopotamia, "by the river Chebar," now *Khabûr*, a stream of considerable length flowing into the Euphrates near Circesium, *Kirkesia*. On this river Nebuchadnezzar founded a Jewish colony from the captives whom he brought from Jerusalem when he besieged it in the eighth year of king Jehoiachim. This colony (or at least a part of it) was settled at a place called Tel-Abib;

Eziongeber || Ezra.

and it seems to have been here that the prophet fixed his residence. He received his commission as a prophet in the fifth year of his captivity (B.C. 594). Ezekiel is remarkably silent respecting his personal history; the only event which he records (and that merely in its connection with his prophetic office) is the death of his wife in the ninth year of the captivity. He continued to exercise the prophetic office during a period of at least twenty-two years, that is, to the 27th year of the captivity; and it appears probable that he remained with the captives by the river Chebar during the whole of his life. That he exercised a very commanding influence over the people is manifest from the numerous intimations we have of the elders coming to inquire of him what message God had sent through him (ch. viii. 1; xiv. 1; xx. 1; xxxiii. 31, 32, &c.) Carpzov (pp. 203–4) relates several traditions respecting his death and sepulchre, principally from the treatise *De Vitis Prophet.*, falsely attributed to Epiphanius. It is there said that he was killed at Babylon by the chief of the people, on account of his having reproved him for idolatry; that he was buried in the field of Maur in the tomb of Shem and Arphaxad, and that his sepulchre was still in existence. Such traditions are obviously of very little value.

Most critics have remarked the vigour and surpassing energy which are manifest in the character of Ezekiel. The whole of his writings show how admirably he was fitted, as well by natural disposition as by spiritual endowment, to oppose the "rebellious house," the "people of stubborn front and hard heart," to whom he was sent. The figurative representations which abound throughout his writings, whether drawn out into lengthened allegory, or expressing matters of fact by means of symbols, or clothing truths in the garb of enigma, all testify by their definiteness the vigour of his conceptions. Things seen in a vision are described with all the minuteness of detail and sharpness of outline which belong to real existences. But this characteristic is shown most remarkably in the entire subordination of his whole life to the great work to which he was called. We never meet with him as an ordinary man; he always acts and thinks and feels as a prophet.

The genuineness of the writings of Ezekiel has been the subject of very little dispute. According to Jewish tradition, doubts were entertained as to the canonicity of the book on the ground of its containing some apparent contradictions to the law, as well as because of the obscurity of many of its visions. These, however, were removed, it is said, by Rabbi Hananias, who wrote a commentary on the book, in which all these difficulties were satisfactorily solved.

EZIONGEBER. See AKABAH.

EZRA, the celebrated Jewish scribe and priest, who, about the year B.C. 458, led the second expedition of Jews back from the Babylonian exile into Palestine. This Ezra was a lineal descendant of Phinehas, the son of Aaron, and ought to be distinguished from the Ezra who went up as one of the chiefs of the priests and Levites under Zerubbabel (Neh. xii. 1–33). In addition to the information given in the books of Ezra and Nehemiah, that Ezra was a "scribe," a "ready scribe of the law of Moses," &c., we are told by Josephus that he was high priest of the Jews who were left in Babylon; that he was particularly conversant with the laws of Moses, and was held in universal esteem on account of his righteousness and virtue.

In the the year B.C. 457 Ezra was sent by "Artaxerxes Longimanus to inquire concerning Judah and Jerusalem; and to carry the silver and gold which the king and his counsellors freely offered unto the God of Israel," with the free-will offerings which the people and priests offered for the house of God at Jerusalem. At the same time Artaxerxes issued a decree to the keepers of the king's treasure beyond the river, to assist Ezra in everything in which he needed help, and to supply him liberally with money, corn, wine, oil, and salt.

Ezra assembled the Jews who accompanied him on the banks of the river Ahava, where they halted three days in tents. On the twelfth day from their first setting out Ezra and his companions left the river Ahava, and arrived safely at Jerusalem in the fifth month, where he shortly after had the painful duty of enforcing the law which forbade the Jews to intermarry with heathens, many of whom had formed such illegal connections in the land of their captivity, and which they were now called on to dissolve.

In Neh. viii. we read that, on the occasion of the celebration of the feast of the seventh month, subsequently to Nehemiah's numbering the people, Ezra was requested to bring the book of the law of Moses; and that he read therein standing upon a pulpit of wood, which raised him above all the people.

Josephus tells us that he died soon after this celebration of the feast of tabernacles, and was buried at Jerusalem with great magnificence. According to other traditions Ezra returned to Babylon, and died there at the age of 120 years. The Talmudic statement is that he died at Zamzumu, a town on the Tigris, while on his road from Jerusalem to Susa, whither he was going to converse with Artaxerxes about the affairs of the Jews. A tomb said to be his is shown on the Tigris, about 20 miles above its junction with the Euphrates.

Ezra is considered to be the author of the canon, and worthy to have been the lawgiver, if Moses had not preceded him.

The *canonical writings* of Ezra are, besides the book which bears his name, most likely the two books of the Chronicles. "Esram libros Paralipomenon lucubrasse Ebræorum omnium est fama consentiens" (Huetius, *Dem. Evang.*, iv. 14, p. 341). Some authors have ascribed the books of Nehemiah and Esther likewise to Ezra, although they differ in style.

F.

F, the fourth consonant and sixth letter of the English alphabet. The letter F is borrowed from the digamma or double gamma, Ϝ, of the Æolians, as is evident from the inscription on the pedestal of the Colossus at Delos; and though this letter is not found in the modern Greek alphabet, yet it was in the ancient one, whence the Latins received and transmitted it to us. It is formed by a forcible emission of the breath and placing at the same time the upper teeth on the under lip. It has but one sort of sound, which has a great affinity with *v* and *ph*, the latter being used by us for the letter φ in all words derived directly from the Greek. The Romans for some time used an inverted F, instead of V consonant, which had no peculiar figure in their alphabet. Thus, in inscriptions we meet with TERMINAꟻIT, DIꟻI, and so on. Lipsius and others say that it was the Emperor Claudius who introduced the use of the inverted digamma or Ⅎ; but it did not long subsist after his death; for Quintilian states that it was not used in his time. F or FA, in *Music*, is the fourth note in rising in this order of the gamut, *ut, re, mi, fa*. It likewise denotes one of the Greek keys in music, destined for the bass. F, in medical prescriptions, stands for *Fiat*, or Let it be done; thus, *f. s. a.* signifies *fiat secundum artem*. F was also a numeral letter signifying forty; according to the verse,

Sexta quaterdenos gerit quæ distat ab alpha.

And when a dash was added at top, thus, $\overline{\text{F}}$, it signified forty thousand. In the civil law, two of these letters together, *ff*, signify the Pandects. In English criminal law (by stat. 4th Henry VII., cap. 13), this letter was branded on felons, on their being admitted to benefit of clergy.

FABII, an illustrious family of ancient Rome, who from the time when they first began to make a figure in history, B.C. 486, till the reign of Tiberius, counted among their honours seven dictatorships, forty-eight consulships, eight censorships, and seven augurships, besides many inferior dignities. In the early times of the republic, it was an honourable distinction in the history of this family, that from 486 to 479 B.C. one of the two consuls was a member of the Fabian house. In that latter year the whole family to the number of 306 left the city, with the intention of taking the war with the Vejentes into their own hands, and settled with their households on the banks of the river Cremera, where they maintained themselves successfully against the enemy for two years. At the end of that period, however, they fell into an ambuscade and were cut off to a man. The only representative of the family at this time surviving was a youth, who, from his tender years, had been left at Rome. He became the ancestor of all the Fabii whose names are afterwards met with in Roman history, of whom the most distinguished were M. Fabius Ambustus, consul in the year of Rome 393, and afterwards re-elected for several successive years; his son Q. Fabius Maximus Rullianus, master of the horse under the Dictator Papirius, in whose absence, and contrary to whose orders, he fought a great battle with the Samnites whom he utterly defeated, but though victorious he made a very narrow escape with his life in consequence of having disobeyed the orders of the commander-in-chief, whom he had deprived of the opportunity of distinguishing himself. But the greatest of the Fabian family, and indeed one of the greatest of all the Romans of the Commonwealth, was Q. Fabius Maximus Verrucosus, the successful opponent of Hannibal in the second Punic war.

FABIUS PICTOR, the father of Roman history, was descended from M. Fabius Ambustus the consul. In the interval between the first and second Punic wars we find him taking an active part in the subjugation of the Gauls in the north of Italy (225 B.C.); and after the battle of Cannæ (216 B.C.), he was employed by the Romans to proceed to Delphi, in order to consult the oracle of Apollo. In his capacity of historian he is worthy of note as the first of the Roman annalists who set the example of writing the history of his country in prose. The rude muse of Nævius had already celebrated in verse the glory acquired by the Roman arms in the first Punic war, and Ennius had clothed the annals of his adopted country in the language of poetry. But till the time of Fabius Pictor, no one had appeared to chronicle in simple prose the *res gestæ* of Rome and the Romans. The sources from which he derived the materials for his history were the oral traditions current among the people, and the annals of the priests; and though his style seems to have partaken much of the dry and jejune character of these chronicles, it is highly praised by Livy (who borrowed very largely from Fabius), as well as by Cicero, Pliny, and many other writers. Polybius has expressed a doubt respecting their credibility, but apparently without sufficient reason. That he should have copied from a Greek writer, Diocles of Alexandria, as Dionysius hints, carries with it its own refutation; but it is a curious fact that he wrote his annals in the Greek as well as Latin language. To what period he brought down his history we are unable to determine. Livy speaks of his death 169 B.C. (Molleri *Diss. de Q. Fabio Pictore*, Altorf. 1689; Lachman, *De Fontib. Livii;* Fabric. *Bibl. Lat.*)

Q. FABIUS MAXIMUS *Verrucosus*. one of the most distinguished Romans of the republic. He first makes his appearance in history as the conqueror of the Ligurians, who had long braved the power of Rome; and though we have no account of his proceedings from this period down to the beginning of the second Punic war, he must have no doubt taken a prominent part in public affairs, as he was then appointed to head the embassy (219 B.C.) sent to Carthage to inquire whether that state approved of Hannibal's conduct in attacking Saguntum. The answer proved unsatisfactory; when Fabius, assuming the haughty dignity of a Roman senator, and folding up his cloak so as to form a cavity, thus addressed the nobles of Carthage: "Hic vobis bellum et pacem portamus; utrum placet sumite." Being answered that he might give which he pleased, he indignantly exclaimed, "Then I give you war;" and the deputies returned to Rome to state the result of their mission. The disastrous campaign on the Trebia, and the defeat on the banks of the Thrasymene Lake, warned the Romans that their successful resistance to Hannibal, and even their existence, depended on the wisdom of the general to whom they entrusted their troops. Everything pointed out Fabius as the person on whom the fate of Rome ought to be allowed to depend. The senate appointed him dictator; and the fearless character of Minucius probably induced Fabius to make him master of the horse, or second in command; and his conduct in that office did not eventually disappoint the expectations of his countrymen. The grand object of his policy was to weary out and exhaust the army of Hannibal, without the risk of a general engagement; and so closely did he adhere to the plan which he had laid down for himself, that he received from this circumstance the name of Cunctator. His slow and cautious policy by no means suited the ardent spirit of the Romans, and more particularly that of Minucius, his master of the horse, who began to ridicule the proceedings of Fabius, and, when he was absent at Rome, took the

opportunity of attacking the enemy, and came off victorious in a small skirmish. This tended only more strongly to confirm the opponents of Fabius in their opinion; and Varro was bold enough to propose that Minucius should be made equal in command with Fabius. The result was exactly such as might have been anticipated. Minucius engaged in battle with Hannibal, and his army was on the verge of ruin when the opportune arrival of Fabius changed the aspect of affairs. Minucius seems to have had the moral courage to confess his folly, and cheerfully to submit to the orders of Fabius. At the end of six months he resigned his dictatorship.

But it was not long before Rome was again obliged to have recourse to the experience of Fabius. After the defeat at Cannæ (216 B.C.), he was appointed, along with Marcellus, to the command of the armies; Fabius being called *the shield*, and Marcellus *the sword*, of the republic. He laid siege to the important city of Capua; and when Hannibal marched towards Rome, threatening the city itself, Fabius remained firmly at his post, trusting in the known bravery of his fellow-citizens. Again, in his fifth consulship, we find him taking the city of Tarentum; and when it was proposed, towards the conclusion of the war, that Scipio should pass into Africa, Fabius was decidedly opposed to the scheme. But he did not live to witness the final success of Scipio, having died at an advanced age, 203 B.C. For the details of his public life see art. ROMAN HISTORY.

FABLE is a word used in several senses, all arising out of that primitive meaning in which it denotes an invented or fictitious story. Its applications to literature are, especially in modern speech, much narrower than those of its root, the Latin Fabula; and the only one of these requiring notice is that in which it is the name of a particular kind of literary composition. A fable is a fictitious story, designed, characteristically and mainly, for illustrating a general or universal truth; and it may thus be said to be an allegory and something more, or an adaptation of the allegory to a special purpose. This description, however, would fairly include the Parable also, between which indeed, and the Fable or Apologue, the line of distinction is not very clear. It is, as commonly taken, no broader than this; that the invention of the latter is carried, while that of the former is not carried, beyond the bounds, not of the probable only, but even of the possible. Jotham's story to the men of Shechem is strictly an apologue, while Nathan's allegorical reproof to David is as strictly a parable; but many other tales would be referred to the one class or to the other, according to the diverse experience of different readers.

The apologue, however, has been worked out in one direction, as to the character of which there can be no dispute. This development constitutes what has been called the Æsopean Fable, in which the imagined actors, or the chief of them, instead of being men, are the lower animals, and sometimes plants or other things really inanimate. This shape of the fable arose in very early times, probably among the Eastern nations; and, passing thence to Greece and Rome, it flourished also profusely in the middle ages. We read of its having become, more than once, an instrument of persuasion in the hands of public men, who aimed at fitting their oratory to the grasp of a semi-civilized people: one instance, probably the oldest of which any record exists, is that which was above referred to, from the Book of Judges; another occurred when the Roman Menenius Agrippa told his tale of the members of the body to the plebeians on the Sacred Mount. In regions widely distant from each other, and in very remote ages, the fable took also a literary shape. It was used for many centuries as a favourite vehicle for the inculcation of rules of practical action, as well as for the venting of satire political and social; and even in modern times it has not altogether lost its ground, having been employed, not unfrequently, and oftenest in the form of verse, for insinuating the minor morals, or for giving point to epigrammatic and stinging jests. It should be noted, indeed, that the nature of the apologue proper unfits it for effectively symbolizing high ethical doctrines: to positions giving occasion for such teaching, its animal or inanimate actors cannot well be made to rise, unless by a looseness of invention that would degenerate into extravagance and absurdity. Accordingly, the framers of apologues have at all times been tempted to wander beyond their own field. In many of the most striking and celebrated fables, the introduction of the animal personages is merely ornamental, the action and its lesson turning really on the thoughts and conduct of human beings who appear along with them; nor is there, perhaps, any extensive collection of fables, whether ancient or modern, invented or compiled, in which an attempt is not made to relieve the monotony by the interspersion of stories having men only as their actors.

It is not probable that we possess any Oriental Apologues, in the state in which they were received by the Greeks. But there are many extant specimens which are very ancient, and which likewise have reached us without any loss of the native Eastern colouring. The most famous of these are contained in the various shapes and versions of a collection, which was long known as the Fables of Pilpay. Hindustan was the birth-place, if not of the originals of these tales, yet certainly, at least, of the oldest shape in which they still exist. The source of all of them is the Sanscrit book called the Pancha Tantra, or Five Sections. It has been analysed by Professor H. H. Wilson in the Transactions of the Asiatic Society; and the Hitopadesa, an alteration of it in the same language, was translated into English by Wilkins. The stories of both works are told in prose, but reflections in verse, chiefly quotations, are interspersed freely. The fables which they contain reached Europe in the middle ages, through translations from an Arabic version (long lost), usually called the "Kalila Damana," from the names of two jackals who figure prominently in it; and the name Bidpai, there given to the wise man who is the story teller, has been changed into Pilpay. There exists in Arabic, also, a much more meagre collection of fables, attributed traditionally to Lokman, who is said to have lived in the time of King David.

The Sanscrit Fables bear the Hindu impress very strongly. The animals, the scenery, and the aspect of society, are all genuinely Indian; and not a few features image vividly the ancient state of Indian greatness and independence. One of the names of the older form of the collection signifies "The Book of Polity;" and the tales are feigned to have been told by a learned Brahmin to the sons of a great king or raja, the education of whom had been committed to him, and was to be effected chiefly through the weighty lessons of wisdom and morality thus communicated. Many stories which afterwards in European hands assumed a domestic and familiar cast, are here invested with royal and aristocratic pomp; the several kinds of animals have their several kingdoms, mixed up together by whimsical borrowings and dependences; and the picture is often embellished also with wild mythological groups. Among other tales found in the collection, which are not properly fables, are the originals of the Arabian Alnaschar, of the story versified in Bethgelert, and of several of the French fabliaux.

The Æsop of the Greeks, the hunchbacked slave and jester, is very like the Lokman of the Arabs; and of the fables which were current in Greece under his name not a few are identical with those of the East. As to all of them, it is quite uncertain who may have been the author or compiler; but Fables attributed to Æsop are quoted, in prose, by Xenophon, Aristotle, Plutarch, and other Greek writers; and Plato represents Socrates as having versified some such in the time of his imprisonment. Babrius or Babrias, who appears to have lived not long before the Augustan age

turned a large number of Æsopean Fables into Greek choliambic verse; and, after these had long been known in fragments only, most, if not all of them, were recovered in a manuscript found in a monastery of Mount Athos in 1844. The London edition of these, that of Sir G. C. Lewis, contains a hundred and twenty-nine fables. They are equal to those of Phædrus for brief expressiveness of phrase, and superior in the apposite pointedness with which, in most of them, the incidents are brought to bear on the moral. It may be worth noting that Babrias introduces the tiger, who, though very prominent in the Oriental apologues, had for a while lost his place among the Greeks. But he leaves the lion in possession of his sovereignty over the brutes; a feature, by the way, whose appearance in the more recent fables is one decisive symptom of their Oriental origin.

To this little corner of literature the Romans certainly supplied nothing better than the one fable, that of the Town Mouse and Country Mouse, told so tersely by Horace in one of his satires. But to the same age belong, not unworthily, the Fables of Phædrus, about ninety in number. They tell, in the easy iambic verse of comedy, and with a grace of style not surpassed by any other Augustan writer, stories, for the invention of which the fabulist professes himself to be indebted to Æsop, and most of which are generally of the Æsopean kind. There is, however, much originality in details. Even when his outline seems to be clearly traceable to some of the Greek stories still accessible, Phædrus often alters very skilfully, for the purpose either of giving a more natural or lively air to the picture, or of fitting the incidents more closely to the moral; and almost everything seems to be his own that strikes us most, in the light touches of characterization, and the occasional strokes of quiet humour. If the extreme brevity which he maintains throughout does sometimes give bareness and dryness to his scenes, it has opened to him the occasions which most of all bring out his mastery of language, while sometimes also it enables him to exhibit much force in concentrating both thought and imagery. A critic who deals very severely with Phædrus has been compelled to allow the excellence of the following fables, which indeed may be taken as fair specimens of his characteristic merits: the Ass and the Old Shepherd (i. 15); the Weasel and the Man (i. 22); the Mule and the Robbers (ii. 7); the Bees and the Drones (iii. 13); the Cicada and the Owl (iii. 16); the Huntsman and his Dog (v. 10).

The Fables of the rhetorician Aphthonius in Greek prose, and those in Latin elegiac verse, attributed to Avianus or Avienus, make, in the history of the apologue, a sort of link between the classical and the dark ages. In that overflowing chaos, which constitutes the literature of the middle ages, the fable reappears in several aspects. In a Latin dress, sometimes in prose, sometimes in regular verse, and sometimes in rhymed stanzas, it contributed, with other kinds of narratives, to make up the huge mass of stories which has been bequeathed to us by the monastic libraries. These served more uses than one. They were always easier reading, and were often held to be safer and more instructive reading also, than the difficult and slippery classics, for those monks who cared for reading at all, and were not learned enough for any pursuit deserving the name of study. For those who were a little more active-minded, they aided the *Gesta Romanorum* and other collections of fabliaux or short novels, in suggesting illustrations available for popular preaching. Among those mediæval fables in Latin, very little of originality is to be detected. The writers contented themselves with working up the old fables into new shapes, with rendering from prose into verse, or from verse into prose; a kind of attempts which had its merit in such hands as those of Babrias or Phædrus, but from which no fruit could be expected to be gathered in the convents. The few monks who could have performed such a task well, aimed wisely at something higher. It might be enough to name, among the monkish fabulists, Vincent of Beauvais, a Dominican of the twelfth century, in whose *Speculum Doctrinale* are a good many prose fables, more than half of them from Phædrus. About the end of the same century, too, a considerable number of fables, some of which have been printed, were compiled by an English Cistercian monk, Odo de Cerinton. Nor was this the only collection that arose in England.

As the modern languages became by degrees applicable to literary use, fables began to appear in them. There still exist, in Norman-French, a good many: of which may be noted the fables called those of Ysopet, and those composed by Marie de France, the authoress of the well-known fabliaux. Later, also, they were not wanting, though not numerous, in our own tongue. Chaucer has given us one, in his story of Chaunteclere and Dame Partelet; another is Lidgate's tale of The Churl and the Bird. But the course of the short and isolated fables through the middle ages is not here worth prosecuting.

Several of Odo's tales, like Chaucer's Æsopean story, must have been derived from some shape or other of a work, or series of works, for the sake of which chiefly the mediæval history of the apologue is interesting. This was the History of Reynard the Fox. Grimm has traced, to as early a date as the middle of the tenth century, the earliest of some extant stories in Latin verse, out of which arose the later poems on the theme, composed in the spoken tongues. The oldest of these was written in High German, probably in the twelfth century: not much later appeared a good many shorter poems in Norman-French; and a Low-German edition of the story "Reineke de Vos" (which has lately been shown to have been founded on an older Flemish original), exhibited the adventures in their fullest elaboration, and became, in its own shape and in translation, popular throughout all Europe. One of our venerable Caxton's labours was a version of a Dutch prose version of it, which he finished in 1481. By the German antiquaries and critics the "Reineke" has been treated with that somewhat overstrained enthusiasm which, since the beginning of the present century at least, they have bestowed so freely on the mediæval monuments of the father-land: a rendering of it into modern hexameters appears among the works of Goethe. It is really a very remarkable piece. In it the Æsopean fable received a development which was in several respects quite original. We have here no short and unconnected stories. Materials, partly borrowed from older apologues, but in a much greater proportion new, are worked up into one long and systematic tale, so as to form what has been quaintly called an animal-romance. The moral, so prominent in the fable proper, shrinks so far into the background, that the work might be considered as a mere allegory. Indeed, while the suspicion of its having contained personal satires has been convincingly set aside, some writers deny even the design to represent human conduct at all; and we can scarcely get nearer to its signification than by regarding it as being, in a general way, what Carlyle has called "a parody of human life." It represents a contest maintained successfully, by selfish craft and audacity, against enemies of all sorts, in a half-barbarous and ill-organized society. With his weakest foes, like Chaunteclere the Cock, Reynard uses brute force; over the weak who are protected, like Kiward the Hare and Belin the Ram, he is victorious by uniting violence with cunning: Bruin, the dull, strong, formidable Bear, is humbled by having greater power than his own enlisted against him; and the most dangerous of all the fox's enemies, Isengrim, the obstinate, greedy, and implacable Wolf, after being baffled by repeated strokes of malicious ingenuity, forces Reynard to a single combat, but even thus is not a match for his dexterous adversary. The knavish fox has allies worthy of him, in Grimbart the watchful badger, and in his own aunt Dame Rukenawe, the learned

She-ape; and he plays at his pleasure on the simple credulity of the Lion-King, the image of an impotent feudal sovereign. The characters of these and other brutes are kept up with a rude kind of consistency, which gives them great liveliness; many of the incidents are devised with much force of humour; and the sly hits at the weak points of mediæval polity and manners and religion, are incessant and palpable.

It is needless, as has already been said, to attempt tracing the appearance which fables, or incidents borrowed from them, make so frequently as incidental ornaments in the older literature of our own country and others. Nor is there here fit occasion for dwelling minutely on the cultivation of the apologue in modern times, as a special form of poetical composition. It has appeared in every modern nation of Europe, but has nowhere become very important, and hardly ever exhibited much originality either of spirit or of manner. In our own language, Prior indicated the possession of much aptitude for it; but neither the fables of Moore, nor even the much more lively ones of Gay, possess any distinguished merit. To Dryden's spirited remodellings of old poems, romances, and fabliaux, the name of fables, which he was pleased to give them, is quite inapplicable. In German, Hagedorn and Gellert are quite forgotten; and Lessing's fables, both in prose and in verse, are chiefly notable for hard thinking and cool satire. The Italian fables of Pignotti are much superior to all of those which have just been referred to.

It is only in France that the Fable has attained, in modern times, a literary position of real eminence; and it has owed this distinction to one writer, whose singular success has been sufficient alike to eclipse predecessors and to discourage all endeavours at imitation. La Fontaine, a man who, both in character and in intellect, was not unlike Goldsmith, was enabled by fortunate circumstances to concentrate his powers more vigorously; while the state of French society, and the turn of French opinions and feelings, brought out clearly some tendencies which in our man of genius were but imperfectly developed. La Fontaine's fables are, beyond all doubt, incomparably superior to everything else of their class. Of his extraordinary mastery in style and versification we foreigners can be only so far sensible, as to share, partly on trust, in the admiration felt for those excellencies by his countrymen. We can appreciate fully, in many instances, the rare pointedness and aptness of brief expression, clothing shrewd and striking apophthegms, which have given to so many of his lines and phrases a place in the common speech of educated men, like that which has been gained in our tongue by many fragments of Pope and by some of Shakspeare. The "Aide-toi et Dieu t'aidera," is but one example of a thousand. We can understand thoroughly, too, his unique mixture of sly sagacity, fine humour, and quiet reflectiveness, with a simplicity, and good-heartedness, and tenderness, which are best describable by the words of his own language—"naiveté" and "bonhommie." The outlines of his stories are chiefly borrowed from Phædrus, Avienus, and the older French fabulists. But among his two hundred and fifty fables there are certainly some whose idea was his own: there has been cited, as one undoubted instance, the ingenious device which he uses in "L'Homme et son Image," for paying a delicate compliment to Rochefoucault. He has, likewise, inexhaustible variety of invention in the filling up of details by original touches, both of incident and of description. Sometimes these are applied merely for giving liveliness and reality to the picture; at other times they suggest humorous images of contrast, as when the lion is described as holding court in his "Louvre," and as issuing his proclamations, "De par le Roi." Often, again, the originality lies in the increase of pointedness and wit with which he throws out the epigrammatic lesson of the old story; a feature which may be exemplified in "L'Ours et les Deux Compagnons," "Le Renard, Le Singe, et Les Animaux," and the tale from Phædrus of "Le Vieillard et L'Ane." He occasionally remodels fabliaux and similar anecdotes; being prompted by a desire both for diversity of incident and for opportunities of insinuating maxims not easily wrapt up in the apologue proper, either because they rise somewhat high in morals, or because they bear on complicated relations of modern society. Some such deviations from the path of the fable are apologized for in light and sparkling passages; as in the introductions to "Tyrcis et Amarante" and "Le Dépositaire." His personal feelings are often brought gracefully into play, and nowhere perhaps so beautifully as in the sentimental reflections which close "Les Deux Pigeons." His favourite manner of narration is broad, garrulous, and studded with particulars; and it thus escapes from the bareness which often chills us in Phædrus. But this fulness is not always unattended by superfluity: "in many of his fables he beats round the subject, and misses often before he hits." This is a remark of Mr Hallam's; who observes, also, that the moral of the tale is kept more directly in view by La Fontaine than by Phædrus. It must be said, however, that the abundance of features sometimes obscures the moral, or suggests, besides the moral which the poet chooses to draw, other inferences both more important and more obvious. The latter case is instanced in "Le Cochon, La Chèvre, et Le Mouton," and "L'Homme et La Couleuvre." Yet, even in such stories, there occurs often a slily good-humoured hint, which shows that the writer had his eyes open. Indeed there is hardly any piece of the collection, that fails to evince the loving zeal which the simple-hearted fabulist lavished on these his favourite works: the general equality of merit among them is very striking; and further, of those which are deformed by faults lying on the very surface, there is not perhaps one which, on narrower scrutiny, does not disclose some counterbalancing beauty of thought or of expression. Thus we have the rich Hermit-Rat ("Le Rat qui s'est retiré du Monde"), who, on an appeal from the starving community of his race, offers his prayers but refuses charity; an incident in the conception of which the idea of animal nature is quite lost sight of. But this very poem has been warmly admired; and the admiration is richly merited by the fine irony, for which the poet has carefully prepared himself in the opening of the story, and which he utters in its close with his most felicitous smile of gay and well-bred satire. (W. S.)

FABRETTI, Raffaele, a celebrated Italian antiquary, was born in 1619, at Urbino, in the States of the Church. At an early age he was sent on important political affairs into Spain; and, on his return, was appointed in rapid succession secretary of the memorials, canon of the Vatican, and keeper of the archives in the Castle of St Angelo, by the Popes Alexander VIII. and Innocent XII. Much of his spare time he devoted to the study of antiquities, and in this pursuit he examined with minute care the numerous monuments and inscriptions of the Campagna. He always undertook his antiquarian expeditions alone, on a horse which his friends nicknamed Marco Polo, and which became so habituated to its master's ways, that it used to stop of its own accord before the objects of which he was in quest, and indeed often rendered him good service by halting in this way before interesting remains which escaped his own eye. In 1680 he published his treatise *De Aquis et Aquæductibus Veteris Romæ;* in which his interpretations of certain passages in Livy and other classics involved him in a dispute with Gronovius, which in its general conduct bore a strong resemblance to that waged between Milton and Salmasius. His other works—*De Columna Trajani*, 1683; and *Inscriptiorum Antiquarum Explicatio*, 1699—throw much light on Roman antiquity, especially with the aid of the principle which he himself employed, of making one monument interpret another. Fabretti died at Rome early in the year 1700.

FABRIANO, Gentile da, an historical painter, was born at Verona in 1332, and became a disciple of Giovanni da Fiesole. He soon acquired a considerable reputation, and was employed to adorn a great number of churches and palaces at Florence, Urbino, Siena, Perugia, and Rome. His picture of the Virgin and Child attended by Joseph, which is preserved in the church of Santa Maria Maggiore, was highly commended by Michael Angelo. At the request of the doge and senate of Venice he painted a picture in the great council-chamber, which was considered so excellent that his employers granted him a pension for life, and conferred upon him the highest honour of their state, namely, the privilege of wearing the habit of a Venetian noble. He died in 1412.

FABRIANO, a city in the delegation of Macerata, Papal States, is situated on the right bank of the Giano, 29 miles W. of Macerata. It has a cathedral and numerous convents, and considerable manufactures of paper and parchment. Pop. about 6000.

FABRICIUS, George, a Latin poet and historian, was born at Chemnitz in Germany, on the 24th April 1516. He began his studies in his native place, and completed them at Freyberg and at Leipzig, where he was preceptor to Wolfgang, and also to Philip and Antony, Werter. He travelled into Italy with the elder of his pupils; and on his return to Germany, in 1553, was appointed director of the college of Meissen, where he died on the 13th July 1571. In his sacred poems, which obtained for their author considerable distinction, he affected not to employ any word which had the slightest savour of paganism; and he blamed those poets who had in their works introduced the pagan divinities. The following list includes the principal works which he published, either as author or as editor: 1. *Terentii Afri Comœdiæ sex cum castigatione duplici Joannis Rivii et G. Fabricii*, Strasburg, 1548, in 8vo; 2. *Roma, sive Liber utilissimus de veteris Romæ situ, regionibus, viis, templis, aliisque ædificiis*, Bâle, 1550, in 8vo; 3. *Virgilii Opera cum commentariis Servii et T. C. Donati*, Bâle, 1551, in fol.; 4. *Virgilii Opera a Fabricio castigata*, Leipzig, 1551, 1591, in 8vo; 5. *Poëmatum Sacrorum libri quindecim*, Bâle, 1560, in 16mo; 6. *Poëmatum veterum ecclesiasticorum opera Christiana et operum reliquiæ ac fragmenta*, 1562, in 4to; 7. *De Re Poëtica libri septem*, 1566, in 8vo; 8. *Rerum Misnicarum libri septem*, 1569, in 4to; 9. *Originum illustrissimæ stirpis Saxonicæ libri septem*, 1597, in fol.; 10. *Rerum Germaniæ magnæ et Saxoniæ universæ memorabilium volumina duo*, Leipzig, 1609, in fol.

Fabricius, or *Fabrizio, Jerome*, surnamed *Acquapendente*, from his having been a native of the episcopal city of that name in Italy, where he was born in 1537. His parents, though poor, were desirous to give their son an excellent education, and with this view sent him to Padua, where the young Fabricius soon found powerful protectors to assist in the cultivation of his talents. After completing his course of philosophy, he applied himself to medicine, which he studied under the celebrated Fallopius, and soon became the most distinguished pupil of that learned professor, whom he afterwards succeeded. Fallopius having died in 1562, Fabricius, then only twenty-five years of age, was at first employed merely to give anatomical demonstrations; but he discharged this duty with so much zeal and ability that, in 1565, he was formally promoted to the chair of surgery, whilst that of anatomy, which had hitherto been considered as merely a dependence or accessory of the other, was declared primary in favour of Fabricius, to whom were also assigned very considerable appointments. And to these preferments the senators of Venice added the highest distinctions which it was in their power to bestow. They granted him privileges not less extraordinary than flattering, gave him precedence of the professors of philosophy, named him citizen of Venice, honoured him with a statue and a gold chain, decorated him with the order of knight of St Mark, constructed a superb anatomical theatre for his accommodation, and assigned him a liberal retiring allowance, with the right of naming his successor. Fabricius practised his profession with much dignity and with rare disinterestedness. Persons of high rank, who were indebted to him for the re-establishment of their health, made up by rich presents for the fees which the generous physician refused; and these Fabricius collected in a cabinet, on the door of which he caused to be inscribed the words *Lucri neglecti lucrum*. He possessed a beautiful country-house, situated on the delightful banks of the Brenta, and still known by the name of *Montagnuola d'Acquapendente*, where, sound in body and mind, loaded with riches, generally esteemed, and enjoying a brilliant reputation, he calculated on spending a happy old age; but his expectations were cruelly disappointed, and his repose was disturbed by envy and ingratitude. It is even said that on more than one occasion he had to defend himself against violent attempts on his life, which even in his own house was not secure. Relations, on whom he had never ceased to lavish favours, unworthily betrayed his confidence, and are suspected, not without reason, of having abridged his days by means of poison. Having attained the age of eighty-two, he died suddenly, in an agony of vomiting, on the 21st May 1619, leaving to his niece a fortune of two hundred thousand ducats, and to the republic of letters the following works, which are much esteemed: *De Visione, Voce, Auditu*, Venice, 1600, in fol.; *De formato Fœtu liber*, Venice, 1600, in fol.; *De Venarum ostiolis*, Padua, 1603, in fol.; *De Locutione et ejus instrumentis*, Venice, 1603, in 4to; *De Brutorum loquela*, Padua, 1603, in fol.; *De Musculi artificio ac Ossium dearticulationibus*, Vicenza, 1614, in 4to; *De Motu locali Animalium secundum totum*, Padua, 1618, in 4to; *De Respiratione et ejus Instrumentis libri duo*, Padua, 1615, in 4to; *De Gula, Ventriculo, Intestinis*, Padua, 1618, in 4to; and also, *De totius Animalis integumentis*, Padua, 1618, in 4to. These different fragments were collected and printed by Bohn, with a preface, under the title of *Opera omni Anatomica et Physiologica hactenus variis locis ac formis edita, nunc vero certo ordine digesta, et in unum volumen redacta*, Leipzig, 1687, in fol. But the Leyden edition, published in 1738, by Bernard-Siegfred Albinus, is preferred to that of Bohn, as containing a life of the author, and the prefaces of the different treatises, which Bohn had unaccountably suppressed. All the writings of Fabricius are truly classical, and fully justify the high reputation of their author. His style is pure, and even elegant; the language of Hippocrates was as familiar to him as that of Celsus; and lucid order pervades all his writings. In regularity of plan and clear luminous method he is unsurpassed. "On a reproché à ce grand chirurgien trop de timidité dans l'exercice de son art, et pourtant nous le voyons," says his French biographer, "pratiquer et perfectionner le trépan, employer avec autant de hardiesse que de talent le bistouri, l'aiguille, le trois-quarts, la rugine et même le fer rouge, quoiqu' en dise Severino. Haller, qui, certes, ne le juge pas avec bienveillance, est forcé de lui rendre justice sur ces divers points." In a word, Fabricius was one of the greatest ornaments of the university of Padua, and one of the most celebrated anatomists and surgeons of the sixteenth century. (J. B—E.)

Fabricius, *Joannes Albertus*, one of the most learned, laborious, and useful of bibliographers, was born at Leipzig, November 11th, 1668. He lost his mother in 1674, and five years afterwards his father, Werner Fabricius, director of music in the church of St Paul at Leipzig, and author of several works, particularly *Deliciæ Harmonicæ*, published in 1657. Joannes Albertus himself commenced his studies under his father, who on his deathbed recommended him to the care of Valentine Alberti. He studied during five years

Fabricius. under Wenceslaz Buhl, and afterwards for some time under J. S. Herrichen; and in 1684 he was sent to Quedlinburg, there to continue his studies under Samuel Schmidt. Having returned to Leipzig in 1686, he was the same year admitted bachelor in philosophy; and in the beginning of 1688 he took the degree of master in the same faculty. He then applied himself to the study of medicine, which, however, he relinquished for that of theology; and having gone to Hamburg in 1693, he proposed to travel abroad, when the unexpected tidings that the expense of his education had absorbed his whole patrimony, and even left him in debt to his trustee, forced him to abandon his project. He therefore remained at Hamburg, where J. F. Mayer employed him in the capacity of librarian. In 1696 he accompanied his patron to Sweden; and, on his return to Hamburg, not long afterwards, he competed for the chair of logic and philosophy. The suffrages being equally divided between Fabricius and Sebastian Edzardi, one of his opponents, the appointment was decided by lot in favour of Edzardi; but in 1699 Fabricius succeeded Vincent Placcius in the chair of rhetoric and ethics, after which he took the degree of doctor in theology at Kiel. In 1701, J. F. Mayer, having established himself at Greifswald, caused the chair of theology in that city to be offered to Fabricius, who, however, refused it on account of his health. But in 1708 he accepted the professorship of theology, logic, and metaphysics, and was preparing to enter on his new office, when the senate of Hamburg induced him to remain, by adding to his charge as professor that of rector of the school of St John, then held by his father-in-law, Schultz. Schultz died in 1709, but Fabricius retained the rectorship two years longer. In 1719 the landgrave of Hesse-Cassel made him so advantageous an offer, that Fabricius was on the point of accepting it; but this time also the magistrates, by a seasonable increase of salary, prevailed on him to remain amongst them. An attempt was subsequently made to draw him to Wittenberg. But Fabricius refused to listen to the proposals which were made to him, and remained at Hamburg, where he died April 30th, 1736.

Besides the time which he had devoted to the duties of his office, Fabricius spent a considerable portion in maintaining an extensive correspondence, and in receiving the visits of foreigners; but he was so laborious that he was nevertheless the author of a great number of works, the list of which, according to Niceron and Reimar, includes as many as a hundred and twenty-eight. It will be sufficient here, however, to indicate the most remarkable of these, which are, 1. *Scriptorum recentium Decas*, Hamburg, 1688, in 4to; 2. *Decas Decadum, sive Plagiarorum et Pseudonymorum centuria*, 1689, in 4to; 3. *Bibliotheca Latina, sive notitia Auctorum veterum Latinorum quorumcunque scripta ad nos pervenerunt*, Hamburg, 1697, in 8vo, a work which was republished in an improved and amended form by J. A. Ernesti, Leipzig, 1773, in 3 vols. 8vo.; 4. *Bibliotheca Græca, sive notitia Scriptorum veterum Græcorum quorumcunque monumenta integra aut fragmenta edita extant, tum plerorumque e manuscript. ac deperditis*, Hamburg, 1705–1728, in 14 vols. 4to, a work which has justly been denominated *maximus antiquæ eruditionis thesaurus*; 5. *Centuria Fabriciorum scriptis clarorum qui jam diem suum obierunt*, 1705, in 8vo, and a second Century in 1727; 6. *Bibliotheca Antiquaria sive Introductio in notitiam Scriptorum qui antiquitates Hebraicas, Græcas, Romanas, et Christianas scriptis illustrarunt*, 1713 and 1726, in 4to; 7. *Centifolium Lutheranum, sive notitia literaria Scriptorum omnis generis de B. D. Luthero*, 1728 and 1730, in 8vo; 8. *Conspectus Thesauri Litterarii in Italia, præmissam habens præter alia notitiam Diariorum Italiæ litterariorum thesaurorumque ac corporum historicorum et academiarum*, 1730, in 8vo; 9. *Delectus argumentorum et syllabus Scriptorum qui veritatem religionis Christianæ adversus atheos, Epicureos, deistas seu naturalistas, idolatras, Judæos et Muhammedanos lucubrationibus suis asseruerunt*, 1721, in 4to; 10. *Salutaris lux Evangelii toti orbi per divinam gratiam exoriens, sive notitia historico-chronologica, literaria ac geographica propagatorum per orbem totum Christianorum sacrorum*, 1731, in 4to; 11. *Hydrotheology*, in German, 1734, in 4to; 12. *Bibliotheca Latina mediæ et infimæ Latinitatis*, 1734–1756, in 5 vols. 8vo. The principal works edited by Fabricius were, 1. *Vincentii Placcii theatrum anonymorum et pseudonymorum*, Hamburg, in two vols. fol.; 2. *Joannis Mabillonii iter Germanicum, et Joannis Launoii de Scholis celebribus a Carolo Magno et post Carolum Magnum in occidente instauratis liber*, 1717, in 8vo; 3. *Anselmi Bandurii Bibliotheca Nummaria*, 1719, in 4to; 4. *Danielis Georgii Morhofii Polyhistor litterarius, philosophicus, ac practicus, cum accessionibus Joannis Frikii et Joannis Mollerii*, 1732, in two vols. 4to; 5. *Bibliotheca Ecclesiastica*, 1718, in fol.; 6. *Codex apocryphus Novi Testamenti collectus, castigatus, testimoniisque, censuris et animadversionibus illustratus*, 1703, in two vols. 8vo; 7. *Codex pseudepigraphus Veteris Testamenti collectus, castigatus, testimoniisque, censuris et animadversionibus illustratus*, 1713 and 1722, in two vols. 8vo.

Fabricius. FABRICIUS, *Johann Christ*, the most celebrated entomologist of the eighteenth century, was born at Tundern, in the duchy of Sleswick, in 1742. After having completed his studies, at the age of twenty he repaired to the university of Upsal, to attend the prelections of Linnæus. How long he remained there is uncertain; but no pupil was ever more indebted to the lessons of his master than Fabricius. All his works on entomology, which have secured to him a well-merited reputation, indicate the precepts, the method, and even the forms of Linnæus, applied to the development of a single new idea, not more fortunate in conception than fruitful in its consequences. Far from disguising the obligations which he owed to his master, Fabricius delighted to expatiate on the happy moments which he had passed in the society of Linnæus; and the grateful scholar has transmitted to us those biographical details, which are not only the most interesting in themselves, but at the same time best fitted to give us an insight into the character of the great naturalist. It was in studying under this master that Fabricius conceived the idea of his system, and formed the project of his labours on insects. The first insect's mouth which he dissected was that of a cockchafer (*Scarabæus stridulus*); he showed it to Linnæus, with the description he had made of it, and proposed to him to employ the organs of the mouth in order to establish the characters of insects, in the new edition of the *Systema Naturæ* which Linnæus was then preparing. The latter encouraged his pupil to pursue this course, but refused to enter on it himself, because, as he said, he was too old to change his method. Forced to choose a profession, Fabricius studied medicine, and at the age of twenty-five took the degree of doctor in physic; but being soon afterwards appointed professor of natural history in the university of Kiel, he devoted himself entirely to his favourite pursuits, and in 1775 published his system of entomology. This work gave a new aspect to the science. Swammerdam and Ray had classed insects according to their metamorphoses; Lister, Linnæus, and Geoffroy, carrying out a suggestion of Aristotle, according to the organs of motion; and some entomologists, as Réaumur, Scopoli, and even Linnæus himself, had employed the nutritive organs in order to characterize distinctively certain genera. But before the time of Fabricius no one had thought of making these the basis of a general classification. This idea was at once new and bold, and the author evolved it with singular ability. In a second work, which he published two years afterwards, he developed the characters of the classes and genera, showing in the preface the advantages of his method, and at the same time excusing its inconveniences. Lastly, in 1778, he published *Entomological Philosophy*, in imitation of the *Botanical Philosophy* of Linnæus; and from this period till his death, that is during the space of more than thirty years, he was incessantly occupied in extending his system, which he reproduced under different forms in the various works which, from time to time, he gave to the world. But in proportion as the number of species increased, the characters of the *genera*, and even of the classes, became more and more uncertain and arbitrary; and with reference to this fundamental point, his later writings are perhaps inferior to those which preceded them. The basis which he had assumed was excellent; but it could only conduct him to a *natural method*, not, as he supposed, to a *system*; and this misconception led him to neglect other considerations which would

have furnished more exact means of classification. Fabricius had a very extensive knowledge of botany, and of the other branches of natural history. He had been appointed counsellor of state to the king of Denmark, and professor of rural and political economy; in which capacity he published, in German and in Danish, several useful works, though much less celebrated than those which appeared from his pen on the subject of entomology. Fabricius died in 1807, at the age of sixty-five, of a melancholic affection, produced, as is alleged, by the bombardment of Copenhagen.

The following is a list of his works:—1. *Systema Entomologiæ*, Flensburg, 1775, in 8vo; 2. *Genera Insectorum*, Kiel, 1776, in 8vo; 3. *Philosophia Entomologica*, Hamburg, 1778, in 8vo; 4. *Species Insectorum*, ibid. 1778, in 2 vols. 8vo; 5. *Mantissa Insectorum*, Copenhagen, 1787, in 2 vols. 8vo; 6. *Nova Insectorum Genera*, in Mem. of the Soc. of Nat. Hist., Copenhagen; 7. *Entomologia Systematica*, Copenhagen, 1792–1796, in 7 vols. 8vo; 8. *Supplementum Entomologiæ Systematicæ*, ibid. 1798, in 8vo; 9. *Systema Eleutheratorum*, Kiel, 1801, in 2 vols. 8vo, with an index; 10. *Systema Rhyngotorum*, Brunswick, 1803, in 8vo; 11. *Systema Piezatorum*, ibid. 1804, in 8vo; 12. *Systema Antliatorum*, ibid. 1805, in 8vo; 13. Description of the *Tipula Sericea* in the Berlin Mem., tome v.; 14. *De Systematibus Entomologicis*, in the same collection; 15. *Considérations sur l'ordre général de la Nature*, Hamburg, 1781, in 8vo; 16. *Traité de la Culture des Plantes à l'usage des cultivateurs*; 17. *Observations sur l'engourdissement des Animaux durant l'hiver*, inserted in the *Mag. de Physique*, tom. ix., 79; 18. *Résultat des Leçons sur l'Histoire Naturelle*, Kiel, 1804, in 8vo; 19. *Sur l'accroissement de la Population, particulièrement en Danemark*; 20. *Eléments d'Economie Politique à l'usage des étudiants*, Flensburg, 1775, in 8vo; 21. *Renseignements Historiques sur le Commerce du Danemark*; 22. *Hvori bestaaer Borgendyd besvaret*; In what consists civic virtue? Copenhagen, 1786, in 8vo; 23. *Sur les Finances et la Dette en Danemark*; 24. *Recueil d'Ecrits sur l'Administration*, Kiel, 1786, and 1790, in 2 vols. 8vo; 25. *Sur les Académies, particulièrement en Danemark*, Copenhagen, 1796, in 8vo; 26. *Voyage en Norwège*, Hamburg, 1799, in 8vo; 27. *Lettres sur Londres*, Leipzig, 1784, in 8vo; 28. *Lettres au sujet d'un voyage fait en Russie*; 29. *Remarques Minéralogiques et Technologiques*; 30. *Remarques sur le Danemark*, written in English, and published by Pinkerton in his *Modern Geography*, 1807.

FABROT, Charles-Annibal, one of the most celebrated jurisconsults of his time, was born in 1580, at Aix in Provence. At an early age he made great progress in the ancient languages and in the civil and the canon law; and in 1609 obtained a professorship in the university of his native town. He is best known by his translation of the *Basilica*, which may be said to have formed the code of the Eastern empire till its destruction. This work was published at Paris in 1647, in 7 vols. fol., and obtained for its author a considerable pension from the Chancellor Seguier, to whom it was dedicated. Fabrot likewise rendered great service to the science of jurisprudence by his edition of Cujas, which comprised several treatises of that great jurist previously unpublished. Among Fabrot's other works, may be mentioned his *Epistola de Mutuo cum responsione Cl. Salmasii ad Menagium*, Leyden, 1645, in 8vo; *Les Antiquités de la Ville de Marseille*, translated from the Latin of J. Raymond de Solier, Marseilles, 1615, and Lyons, 1632, in 8vo; *Exercitationes duæ de tempore partûs humani et de numero puerperii*, Aix, 1629, in 4to; *Prælectio in titulum Decretalium "De vita et honestate Clericorum,"* Paris, 1651, in 4to; *Notæ at titulum Codicis Theodosiani*. "*De paganis sacrificiis et templis*," Paris, 1648, in 4to.

FABYAN, Robert, an ancient English chronicler, was sprung from a respectable family in Essex, and is believed to have been born in London about the middle of the fifteenth century, though no records remain by which the events of his early life can be assigned to any precise date. The first fact in his history known for certain is, that he was alderman for the ward of Farringdon-Without; and in 1493 he was appointed to the office of sheriff. In 1502, though he is believed on good grounds to have been very rich, he resigned the former of these two offices on the score of poverty, not wishing probably to be elected to the expensive position of Lord Mayor, as he had a very numerous family. Stowe, in his *Survey of London*, states that Fabyan died in 1511; but Bayle, probably with more correctness, assigns that event to the following year. Fabyan's Chronicle embraces the history of England from the time when "Brute entryd firste the Ile of Albion" to the year 1485; and in subsequent editions was continued by unknown authors to the year 1559. There have been five editions of the work, the first of which was printed in 1516 by Pynson, and, as Wolsey ordered many copies of it to be buried, is now very rare; the second by Rastell in 1533; the third by Reynes in 1542; the fourth by Kyngeston in 1559. The fifth, in the preparation of which all the previous editions were compared, was published by Sir Henry Ellis in 1811. The first edition had no regular title; later ones bore the title of the *Concordance of Histories*, it being Fabyan's object to reconcile in his work the conflicting narratives of previous historians. The title of the last edition is "*The New Chronicles of England and France*, in two parts, by Robert Fabyan, named by himself the *Concordance of Histories*."

FACCIOLATI, Jacopo, one of the best of modern Latin scholars, was born in 1682 at Toriggia, in the province of Padua. He published improved editions of several philological works, such as the *Thesaurus Ciceronianus* of Nizolius, the polyglot vocabulary known under the name of *Calepino*, and others. But his fame chiefly rests on his *Totius Latinitatis Lexicon*, 4 vols. fol., Padua 1771. In the compilation of this work the chief burden seems to have been borne by Facciolati's pupil Forcellini, to whom however the lexicographer allows a very scanty measure of justice, though the work occupied thirty years of his life. This lexicon is the best Latin dictionary that has hitherto been published in any country, and is so comprehensive that it has been remarked—that if the whole body of Latinity were now to perish, it might be restored from this work. Facciolati's mastery of Latin style as displayed in his epistles has been very much admired for its purity and grace. In 1722 Facciolati had been appointed professor of logic in the university of Padua, and despite the many flattering invitations he received to exchange this office for others still more honourable and lucrative, he continued to occupy that chair till his death in 1769, in the 88th year of his age.

FACIAL ANGLE. See Anatomy, vol. iii., 30.

FACIES HIPPOCRATICA, in *Medicine*, the peculiar expression of countenance which indicates the approach of death. The several peculiarities incident to this last stage of existence are minutely described by Hippocrates; whence the term.

FACTION (*factio*), a term applied in an ill sense to any party in a state that offers uncompromising opposition to the measures of the government, or that endeavours to excite public discontent upon unreasonable grounds.

Among the ancient Romans, the charioteers in the circus were divided into four parties (*factiones*), each distinguished by the colour of its dress. These factions were thence denominated the white, the red, the blue, and the green; to which Domitian added two more—the golden, and the purple. The spectators favoured one or the other, as humour or caprice inclined them; and it appears, according to Pliny (Ep. ix. 6), that they were more influenced by the gay accoutrements, than by the fleetness of the horses or the skill of the charioteers. It is related that in the time of Justinian no fewer than 30,000 men at Constantinople lost their lives in a tumult that arose among the partisans of these several colours.

FACTOR. See Agent.

Factor, in *Multiplication* and *Algebra*, a name given to the multiplier and multiplicand, or to each of the quantities which are multiplied into one another in order to *form* the product. See Arithmetic and Algebra.

FACTORY. See Manufactures.

Factory, in *Commerce*, a name given to establishments of merchants and factors in foreign countries, where they negotiate business for themselves and their employers. The British possess factories of this kind in China, Turkey, and other distant parts of the world.

FACULÆ, in *Astronomy*, certain spots occasionally seen on the disc of the sun. See Astronomy, iv., 28., &c.

FACULTY, in *Law*, a privilege granted to a person by favour or indulgence, to do that which by law he may not do. Thus the Archbishop of Canterbury has a court of faculties for granting certain privileges and dispensations; such as liberty to marry without the publication of banns, to ordain a deacon under age, &c.

Faculty, in a university, one of the particular departments of learning. In most universities there are four faculties; viz. that of arts (including humanity and philosophy); that of theology; that of medicine; and that of law. See Universities.

Faculty, *Dean of*. See Dean.

FAENZA, the ancient *Faventia*, a town in the delegation of Ravenna, Papal States, situated in a fertile plain at the junction of the canal of Zanelli with the Lamone, 20 miles S.W. of Ravenna. Pop. about 20,000. It is regularly built, and is surrounded by walls, and defended by a citadel. Around the market-place (a spacious square in the centre of the town, with a fine marble fountain) are ranged the cathedral, town-hall, theatre, and many handsome private residences. Faenza possesses numerous churches and monasteries, a lyceum, college, school of painting, hospital, and two orphan asylums. A kind of porcelain which has been supposed to take its name of *faience* from this town, one of the earliest sites of this peculiar product, still continues to be manufactured here, though not to such an extent as formerly. Faenza has also manufactories for spinning and weaving silk, some paper-mills, and a considerable trade by the Zanelli canal. Faventia is noted in history as the place where Carbo and Norbanus were defeated with great loss by Metellus, the general of Sulla, in B.C. 82. In the time of Pliny it was celebrated for its manufactures of linen, which was considered to surpass all other linens in whiteness. Torricelli the famous natural philosopher was born here.

FAERNUS, Gabriel, a distinguished modern Latin poet and critical scholar, was born at Cremona early in the sixteenth century, and died at Rome in 1561. His claims to distinction as an original author depend chiefly on his *Fabulæ Centum ex antiquis auctoribus delectæ*, which have been greatly admired for the purity and elegance of their diction and the skill which they show their author to have possessed in imitating the classical tone and modes of thought. Faernus rendered good service to literature by his edition of Terence, his notes on which were esteemed by Bentley so highly, that he incorporated them bodily in his own edition of that poet. His other works are not possessed of much intrinsic value.

FÆSULÆ (now Fiesole), in *Ancient Geography*, an important city of Etruria, situated on the side of a hill sloping down to the Arno, about three miles from Florence. It was a place of great antiquity, and in the old Etrurian times its inhabitants were famous for their skill in divination. Fæsulæ was a place of some note in the Gallic and Punic wars, and was afterwards selected by Sulla as a site for a colony of his veteran soldiers. These colonists, twenty years later, rendered themselves formidable to the Roman state by the support which they gave to Catiline when organizing his conspiracy, and the town itself was selected by the leader of the revolt for his head-quarters in his attempt to maintain himself against the armies of Metellus and Antony. The story of Catiline and his exploits became engrafted on the early legendary history of Florence, in which his memory is still preserved as that of a national hero. From this time Fæsulæ gradually sank in importance, and though it offered a protracted and vigorous resistance to the arms of Belisarius, it finally fell into decay before the increasing power and prosperity of the adjoining Florence. It is said to have been finally destroyed by its powerful neighbour in the beginning of the eleventh century; but this is a point still contested among historians. The modern Fiesole is a small town with about 2400 inhabitants. It still retains, however, its ancient rank as an episcopal city; and its cathedral is a handsome building adorned with some good paintings and pieces of sculpture.

FAGGING, a term used more particularly to denote a degrading species of servitude still (1855) authorized at Eton, and perhaps imitated in one or two other schools, by which the junior boys (or those of the lower school as it is called) are compelled to act in the capacity of servants, or "fags," to the older or more advanced pupils. Several attempts have of late years been made to abolish this remnant of barbarism,—a reform, it is to be hoped, that will soon be effected.

FAGGOT, a bundle of sticks or small branches of trees bound together. The faggots used in fortification, for raising batteries, filling ditches, &c., are termed *fascines*.

In times of religious persecution, the faggot was used as a badge, worn on the sleeve of the upper garment, to mark that the wearer had recanted or abjured his obnoxious opinions, and had done penance by carrying a faggot to some place appointed for the occasion.

The term faggot was also formerly a cant phrase in the army for a person hired to appear at musters, in order to conceal the deficiency of a company.

FAGUS, the beech. See Planting, and Timber.

FAHRENHEIT, Gabriel Daniel, well known for the modifications which he introduced in the construction of the thermometer and barometer, was born at Dantzic about the end of the seventeenth century. After engaging for some time in commerce, his inclination for natural philosophy induced him to relinquish business; and having travelled through Germany and England to enlarge his knowledge, he settled in Holland, where the most celebrated men in this branch of science—s'Gravesande and others—were his teachers and friends. In 1720 he first conceived the idea of substituting mercury for spirits of wine in the construction of thermometers—an improvement which greatly enhanced the accuracy of the instrument. He took as the limit of greatest cold that which he had observed at Dantzic during the winter of 1709, and which he could always produce artificially by a mixture of equal quantities of snow and sal-ammoniac. The space between the point to which the mercury fell at this temperature and that to which it rose in boiling water, he divided into 212 parts; and this distinguishes his thermometric scale from that of Réaumur.

During his residence in Holland, Fahrenheit employed himself in constructing a machine for draining the parts of the country exposed to inundations; for which he obtained a patent; but its full development was interrupted by the death of the inventor, which took place in 1740. The changes which s'Gravesande introduced (whom he had requested to complete the machine for the benefit of his heirs), rendered it so useless in the first trial that no further attempt was made to complete it. (See Thermometer, and Meteorology.)

FAIENCE, an old French term under which were comprised all descriptions of glazed earthenware, even inclusive of porcelain. The word is still employed in this sense, and corresponds in its general use to the English word crockery. The name is commonly supposed to be derived from Faenza; but it may well be doubted whether upon any authority much to be relied on, since neither historians nor topographers seem to have considered the matter worthy of their attention or examination. (Marryat *on Pottery*, p. 244.)

FAIFO, a town of Cochin-China, situated about ten miles from the sea, on a navigable river, fifteen miles south of Huron. It was at one time a place of some importance, with houses built of brick, and the streets regularly laid out. It was, however, destroyed in the course of the revolutions which took place in the country; but its prosperity is revived, and it is now a place of considerable trade.

FAINTING. See SYNCOPE.

FAIRS AND MARKETS. The intimate relation that subsists between these institutions renders it no less proper than convenient to treat of them together. A fair may be defined as only a greater species of market, which recurs at more distant intervals. Both are appropriated to the sale of one or more kinds of goods, the hiring of servants, labourers, &c. In most cases, however, fairs are more numerously attended than markets, and are generally characterized by various exhibitions got up for the amusement of the people.

The Anglo-Saxons are supposed to have derived their fairs from the Romans, who had established such marts in all their provinces.

The following account of fairs is given by Mr M'Culloch, in his *Dictionary of Commerce*. "Institutions of this sort are peculiarly serviceable in the earlier stages of society, and in rude and inland countries. The number of shops, and the commodities in them, are then either comparatively limited, or they are but little frequented by dealers; so that it is for the advantage of all that fairs should be established, and merchants induced to attend them. For this purpose various privileges have been annexed to fairs, and numerous facilities afforded to the disposal of property in them. To give them a greater degree of solemnity, they were originally, both in the ancient and modern world, associated with religious festivals. In most places, indeed, they are still held on the same day with the wake or feast of the saint to whom the church is dedicated; and till the practice was prohibited, it was customary in England to hold them in churchyards. (*Jacob's Law Dict.* art. *Fair.*) But since the growth of towns, and the opportunities afforded for the disposal and purchase of all sorts of produce at the weekly or monthly markets held in them, the utility of fairs, in this country at least, has very much diminished; they have also lost much of their ancient splendour; and, though some of them are still well attended, and of real use, a good number might be advantageously suppressed.

"But it is far otherwise in inland countries, where the facilities for carrying on commercial transactions are comparatively circumscribed. There it is of the utmost importance that certain convenient places and specified periods should be appointed for the bringing together of commodities and dealers. This is not only the readiest and best means of promoting commerce, but also of softening national antipathies, and diffusing a knowledge of the products, arts, and customs of other countries."

In England the right of holding a fair must be derived from the crown; and, in the grant obtained, provision is made that no other fair shall be injured by the one to be established. The times of holding the fairs are determined by the letters-patent appointing the fair or market, or by usage; and penalties are imposed if they are held beyond the time specified. A *bona fide* sale made in a fair or open market, in general transfers the complete property of the things sold to the vender, so that, however vicious or illegal the title of the vender may be, the vendee's is good against every one except the king. But the sale, in order to come within this rule, must be made on the market day, and at the place assigned for the market. Formerly the mayor or steward presided at a court called the court of *pié poudre*, in allusion to the dusty feet of the suitors, where questions as to contracts, &c. were decided; but these courts are now entirely set aside. Still, as of old, however, there is a clerk appointed, whose duty it is to see that every thing is sold according to just weights and measures. There is generally a toll attached to fairs and markets, which is paid by the buyer after the thing brought to the market has been sold. (For further information as to British fairs and markets, see Chitty *On Commercial Law*, vol. ii.)

British Fairs. Amongst these may be specified that of Stourbridge, in Worcestershire. Bristol has two considerable fairs, one in March and one in September. Exeter December fair is for cattle, horses, and most sorts of commodities. Weyhill fair, in Hampshire (October 10), has probably the greatest display of sheep of any fair in the kingdom. Bartholomew fair, in London, used to be of considerable importance, but is now appropriated only to shows of wild beasts, and such like exhibitions, and might be suppressed with advantage. St Faith's, near Norwich (October 17), is the principal English fair for Scotch cattle. They are sold to the graziers and feeders of Norfolk, Suffolk, Essex, and other counties, by whom they are fattened for the London markets, where the demand for them is very great. But besides those sold at St Faith's, large numbers of Scotch cattle are disposed of at Market-Harborough, Carlisle, Ormskirk, and other places. Ipswich has two considerable fairs; one in August for lambs, and one in September for butter and cheese; and it is reckoned that above 100,000 lambs are annually sold at the former. Woodborough-hill, in Dorset, is for west-country manufactures, as kerseys, druggets, &c.; and Woodstock October fair, for cheese. Northampton and Nottingham have each several large fairs, for horses, cattle, cheese, &c. The August fair of Horncastle, in Lincolnshire, is the largest horse fair in the kingdom, many thousand horses being exhibited for sale during its continuance; and it is resorted to by crowds of dealers from all parts of Great Britain, by several from the Continent, and sometimes even from North America. Howden, in Yorkshire, has also a very large horse fair, particularly for Yorkshire hunters. Devizes, in Wiltshire, has several large fairs for sheep and cattle. There is usually a large display of cheese at the Gloucester April fair. A guild, or jubilee, commencing the last week of August, is held every twentieth year at Preston, in Lancashire: the last was held in 1842, and was well attended. The October fair of Market-Harborough, Leicestershire, lasts nine days, and a great deal of business is usually done in cattle, cheese, &c. Woodbridge Lady-day fair is celebrated for the show of Suffolk horses. Falkirk fair, or tryst, is one of the most important in Scotland, for the sale of cattle and sheep. Hardly inferior are those of Melrose and Lockerby, which have of late years risen into great importance as lamb-markets, and that of Muir-of-Ord, near Beauly, in Ross-shire. The October fair of Ballinasloe, in the county of Galway, is famous for the display of cattle and sheep; by far the largest proportion of these animals raised for sale in Connaught being disposed of at it.

French Fairs. The principal French fairs are those of Beaucaire, St Germains, St Cloud, Poissy, Lyons, Rheims, Chartres, Rouen, Bordeaux, Troyes, and Bayonne; but they are said to have for the most part much fallen off. That of Beaucaire, however, which was formerly the greatest in Europe, is still attended by a vast concourse of people, not only from France, but also from many parts of southern Europe.

German Fairs. The principal German, or rather European fairs, are those of Frankfort on the Maine, Frankfort on the Oder, and Leipzig. The business transacted at these fairs is in general very great. Merchants of all nations are there assembled, for disposing of the manufactures, merchandise, and productions for which their several countries are distinguished. Frankfort on the Maine has two, and Frankfort on the Oder three fairs yearly. Leipzig has also three annual fairs, and these are by far the most cele-

brated. They are held on the first of January, at Easter, and at Michaelmas. The first is the least important. The two latter, particularly that at Easter, are remarkable for the vast number of new publications usually offered for sale. They are attended by all the principal booksellers of Germany, and by many from the adjoining countries, who adjust their accounts, learn the state of the trade in all parts of the world, and endeavour to form new connections. Most German publishers have agents in Leipzig, which is to the literature of Germany what London is to that of Great Britain. As many as five thousand new publications have been entered in a single Leipzig catalogue. The fairs ought to close in eight days, but they usually continue for about three weeks.

Italian Fairs. Of these, the most celebrated is that of Sinigaglia, on the Misa. It commences on the 20th of July, and continues for about twenty days. Here, as at the German fairs, are assembled merchants from almost all nations.

Hungarian Fairs. Of these, the most important are held at Pesth, which has become the grand centre of Hungarian commerce.

Russian Fairs. These are numerous, and many of them are well attended. The most important is held at Nishnii-Novgorod, a city situated at the confluence of the Oka with the Wolga. It is the great emporium of the internal trade of Russia. The fair generally lasts from six weeks to two months, and is well known all over the east of Europe. In point of value this fair is considered as second to none in Europe. Another celebrated Russian fair is that of Kiachta, on the Chinese frontier. At this fair by far the largest part of the commerce between the Russian and Chinese empires is transacted. The goods disposed of are principally the products of the respective countries.

Eastern Fairs. The most important fair in the eastern world is that held at Mecca, during the resort of pilgrims in the month of Dhalhajja. It has declined of late years, but the concourse which attends it is still very great. The greatest fair in India is that held at Hurdwar in Hindustan. The town, although inconsiderable, is famous for being one of the principal places of Hindu pilgrimage, which takes place along with the fair at the vernal equinox.

American Fairs. The fairs of Portobello, Vera Cruz, and Acapulco, once so famous, are now totally deserted; and that of the Havannah is also much fallen off.

FAIR ISLE, one of the Shetland Islands, lying between that group and the Orkneys, and extending fully three miles in length by about two in breadth. The coast, which is abrupt and dangerous, is only accessible on the south-east side; and the hills which cover the interior are only useful as affording pasture for sheep. The inhabitants are very few in number.

FAIRFAX, EDWARD, the able English translator of Tasso, was a native of Yorkshire, son of Sir Edward Fairfax of Denton. Little is known of his history; he is believed to have been an illegitimate son; and though liberally provided for by his father, he continued in obscure retirement at home, while the other sons of Sir Edward Fairfax were distinguished for their military services. Edward Fairfax, however, no less signally served his country by his pen than his brethren did with the sword. In the year 1600, when he is conjectured to have been little more than twenty years of age, he published his translation of the *Jerusalem Delivered* of Tasso. Never did mere translation receive such enthusiastic and continued approbation as the work of Fairfax. Waller said he was indebted to it for the harmony of his numbers; Dryden places the translator almost on a parity with Spenser (whom undoubtedly Fairfax imitated); and Collins beautifully apostrophises him as

> "Prevailing poet, whose undoubting mind
> Believed the magic wonders which he sung."

In our own day, Thomas Campbell has reckoned Fairfax's work as one of the glories of the reign of Elizabeth, while Mr Hallam, more critical, admits that if it does not represent the grace of its original, and deviates also too much from its sense, it is by no means deficient in spirit and vigour. The poetical spirit of the translation is indeed its life-blood and preservation. Hoole, Hunt, and others, may give a more literal version, but Fairfax alone seizes upon the poetical and chivalrous character of the *Jerusalem*, and carries along with him the interest and admiration of the reader. The style of Fairfax is also remarkable, and is characterized by great ease and sweetness of versification. Fairfax made no other appeal to the public. He wrote a series of *Eclogues*, one of which, the fourth, is published in Mrs Cooper's *Muses' Library*, a modern compilation; while the others remain in manuscript. He wrote also a work on *Demonology*, which is still in manuscript. This should surely see the light. It would be interesting to trace the effect of superstition on Fairfax's own mind, and to estimate its height in the age in which he lived. A fragment of the work relative to the author has been printed, and in this Fairfax describes himself in these terms:—"I am in religion neither a fantastic Puritan nor superstitious Papist; but so settled in conscience that I have the sure ground of God's word to warrant all I believe, and the commendable ordinances of our English Church to approve all I practise; in which course I live a faithful Christian and an obedient subject, and so teach my family." He appears, however, to have taken a warm interest in the religious controversies of the day, which are seldom conducive to quiet or contentment, and his descendants have not deemed it necessary to publish his prose MSS. on those subjects. His fame is secure, grafted upon the stem of Tasso, and flourishing in perennial beauty and vigour. Fairfax was living in 1631; the date of his death has not been recorded. (R. C—S.)

FAIRFAX, *Thomas Lord*, who acted so conspicuous a part during the civil wars, was the eldest son of Ferdinand Lord Fairfax, by Mary, daughter of Edmund Sheffield, Earl of Mulgrave, and was born at Denton in the parish of Otley, Yorkshire, in the month of January 1611. After studying at St John's College, Cambridge, he proceeded to Holland, where he served as a volunteer under Horatio Lord Vere. On his return to England he married a daughter of that officer. When Charles I. endeavoured to raise a guard for his own person at York, intending it, as the event afterwards proved, to form the nucleus of an army, Fairfax was employed to present a petition to his sovereign, entreating him to hearken to the voice of his parliament, and to discontinue the raising of troops; and when Charles attempted to avoid receiving it, Fairfax followed him with the petition, which he presented upon the pommel of his saddle, in Heyworth-moor, before an assemblage of nearly a hundred thousand persons. Shortly afterwards, upon the breaking out of the civil war, his father having received from the parliament a commission appointing him general-in-chief of the forces in the north, Fairfax was at the same time made general of the horse under him. In this war, both father and son distinguished themselves by their bravery, intelligence, and activity, particularly at the battle of Marston-Moor and the taking of York; Thomas Fairfax having been twice severely wounded, and having frequently exposed his life in the most daring manner. In 1645, when it was judged expedient to new-model the army, and to deprive Essex of the command, the parliament, knowing that Fairfax was a zealous Presbyterian, unanimously appointed him as successor to Essex. In this command Cromwell was joined with him in the capacity, and with the title, of lieutenant-general.

As soon as Fairfax, who was then in the north of England, received the orders of parliament, he repaired to London, where he arrived on the 18th of February 1645, and

was presented to the House of Commons on the following day by four members, and complimented by the speaker, who handed him his commission. He had full powers to name all the generals under his orders; and in the month of April he proceeded to Windsor, where he employed himself in organizing the new army which the parliament had just voted. After various movements, the hostile armies met on the 14th of June at Naseby, in Northamptonshire, and a battle took place, which ended in the total discomfiture of the royalists. The king was obliged to fly from the field, and retired into Wales. On the 16th the victorious Fairfax laid siege to Leicester, which surrendered two days afterwards. On the 10th July he offered battle to Lord Goring, who had been obliged to raise the siege of Taunton; on the 22d he carried Bridgewater by assault, and thereafter took several other places; and on the 10th September he forced Bristol to capitulate. Having reduced to subjection the whole country to the west of London, he next marched to the south; but finding it impossible, from the rigour of the season, to besiege Exeter, a well fortified city, in regular form, he converted the investment into a blockade, which lasted until the 13th of April 1646. In this interval he took several places, defeated and dispersed different bodies of royalists, and completely humbled, or rather annihilated, this party in the provinces of the south and west, which had formed its great stronghold and constituted its principal resource in England. Having obtained these successes, Fairfax marched in all haste to Oxford, where was the most considerable garrison that yet remained to the king. But the latter, afraid of being shut up in the place, and thus falling into the hands of his mortal enemies, withdrew secretly and proceeded to Newark, to throw himself into the arms of the Scotch. Oxford capitulated; and by the end of September Charles had neither army nor garrison in England.

Fairfax having arrived in London on the 12th November, was complimented and thanked for his successes by the two houses of parliament. But he had scarcely time to enjoy a little repose from the fatigues of war, when he received a commission to escort the two hundred thousand pounds granted by the English parliament to the Scotch army, in name of arrears of pay, but, in reality, according to some, as the price of the king's person, which that army had consented to give up. Charles was delivered up to the commissioners of parliament on the 30th January 1646. Fairfax, who preceded the king, having met him beyond Nottingham, dismounted from his horse, kissed the royal hand, and having resumed his seat, discoursed with the unfortunate prince during the journey to Holdenby. That Charles was satisfied with the conduct of Fairfax, appears from the observation which he addressed to one of the parliamentary commissioners. "The general," said he, "is a man of honour, and keeps his word which he had pledged to me. Fairfax was received at Cambridge with the greatest honours, and created master of arts. By this time the parliament, after long debates, had appointed him general of the forces, which were still to be kept on an effective footing; for it was now intended to disband the greater part, and send the remainder to Ireland. But the soldiers being extremely dissatisfied with a project which threatened to deprive them of all the advantages they had reaped from the war, Cromwell, who had hitherto allowed Fairfax to enjoy in appearance the honours of supreme command, resolved, in concert with Ireton, his son-in-law, to profit by this disposition of the army, in order to foment a revolt against the parliament. Fairfax observed with regret that these agitators, as they called themselves, had usurped the power which he should have exercised over the army; he discerned that they were the forerunners of anarchy, and that their design was to raise their own fortune on the ruin of the state. He therefore resolved to resign his commission; but the chiefs of the Independents, whose projects were not fully matured, persuaded him to retain it. He then, with culpable weakness, co-operated in all the proceedings of the army, which had for their object to destroy the power of the parliament. In vain did the two houses enjoin him to leave his troops at the distance of at least 15 miles from London; he entered that city in triumph, with the speaker and sixty members of the House of Commons, who, betraying the privileges of parliament, had retired to the camp, and whom he now re-instated in their places. Having soon afterwards learned that the king had been removed by violence from Holdenby, Fairfax, indignant at this proceeding, repaired to the place where this unfortunate prince was detained near Cambridge, conducted himself towards the royal captive in the most respectful manner, and caused him to follow all the movements of the army, in order that the parliament might not obtain possession of his person, for which purpose commissioners had already been named by both houses. The credit of Fairfax with the troops, however, diminished daily; he had neither firmness of will nor force of character sufficient to oppose himself to a power which had long overtopped his own; and although he had in view none of the objects which Cromwell cherished, he contributed to render them all successful. It was doubtless in consequence of this inconceivable weakness that he concurred in the manifesto of the army, published in the month of January 1648, which adhered to the vote of the commons, that no more addresses or messages should be presented to the king, and protested that it would obey parliament in everything which might henceforth be necessary for the government of the kingdom and the safety of parliament, whether with the king or against him.

At this period (1647), Fairfax lost his father, whom he succeeded in his titles and employments; but still he remained, as before, the instrument of the ambition of Cromwell. He displayed the greatest activity in putting down insurrections, and took Colchester, whither the remains of the royalist party had betaken themselves. He caused Lord Lisle and Sir Charles Lucas, who had defended Colchester, to be executed—an act of harsh severity, if not contrary to the terms of capitulation. At the end of the year he returned to London, in order to keep in check that city and the parliament; and he took up his head-quarters in the palace of Whitehall. All his proceedings served to accelerate the crisis of the king's fate; but although placed at the head of the judges before whom Charles was to be tried, he refused to act, probably at the instigation of his wife, who on this occasion displayed great boldness and intrepidity. He even exerted himself to prevent the execution of the sentence, and tried to persuade his regiment to rescue the king from the hands of those who had condemned him to death. But Cromwell and Ireton, ably assisted by Harrison, imposed on the pious credulity of Fairfax; and kept him at a distance from Whitehall engaged in religious exercises, until the fatal blow was struck. A few days after the execution of Charles, he was appointed a member of the council, but refused to sign the form of oath by which all that had been done relative to the king and to the royal authority was approved of. Towards the end of March he received the title of general of the troops in England and in Ireland; but he no longer possessed any real power. He marched against the Levellers, who having become numerous, had occasioned considerable uneasiness and would soon have rendered themselves formidable, and completely routed them at Burford in Oxfordshire. He then repaired to Oxford, where he received the degree of doctor of laws; after which he proceeded to allay the troubles in Hampshire, assembled the army in Guildford, exhorted it to obedience, and returned to London, where he was presented with a basin and ewer of beaten gold. In June 1650, when the Scotch had declared for Charles II., the council of state

in England having resolved to send an army to Scotland, in order to prevent an invasion, Fairfax was consulted respecting the design, which he appeared at first to approve; but afterwards declared himself satisfied that the parliament of England had no just ground for sending an army to invade Scotland; and, in terms of this declaration, he resigned his commission. The supreme command of the army was then conferred upon Cromwell, who saw with pleasure the retirement of a man who, being no longer necessary to his ambitious projects, now formed an obstacle to their entire accomplishment. The parliament, however, in some measure indemnified Fairfax, by granting him a pension of five thousand pounds sterling.

Being thus released from all public employment, Fairfax retired to Nunappleton, Yorkshire, where he passed his time in tranquillity, earnestly praying, it is said, for the restoration of the royal family. When General Monk invited him to assist in the operations about to be undertaken against Lambert's army, he promptly obeyed the call, and on the 3d December 1659 appeared at the head of a body of Yorkshire gentlemen; and such was the influence of his name and reputation, that the Irish brigade, consisting of twelve hundred horse, quitted Lambert's colours and joined him; an event which was speedily followed by the breaking up of all Lambert's forces. On the 1st January 1660 he made himself master of York; and on the 2d he was chosen by the Rump Parliament one of the council of state, an appointment which was renewed on the 23d of February ensuing. On the 29th of March he was elected one of the knights of the county of York in the healing parliament; and he was put at the head of the commission appointed by the House of Commons on the 3d of May, to wait upon Charles II. at the Hague and urge his speedy return. After the dissolution of the healing parliament, which was of short duration, he again retired to his seat in the country, where he lived in a manner strictly private till his death, which happened on the 12th of November 1671, in the sixtieth year of his age. The integrity of Fairfax has never been doubted. He was a brave and honest soldier, but great only in the field. He had none of the qualities of a statesman, and though praised by Milton for "firm unshaken virtue," he was in reality deficient in moral courage and consistency. He seems to have oscillated between the counsels of his wife, "one of the fighting Veres and given to Presbyterianism," as Mr Carlyle says, and the influence of Cromwell, whose strong decisive character was a contrast to that of Fairfax his general-in-chief. Lord Fairfax had a taste for literature, and both at York and Oxford endeavoured to save the libraries from pillage. He enriched the Bodleian library with some valuable MSS. He wrote some poetical and miscellaneous pieces, including a sketch of his own life. His correspondence was published in 1848-49. (R. C—S.)

FAIRFORD, a market-town of Gloucestershire, on the small river Colne, 23 miles E.S.E. of Gloucester, and 79 miles from London. It is noted for its parish church, a fine Gothic edifice erected about 1470, and having a remarkably fine series of painted windows. Pop. of parish (1851) 1859.

FAIRIES, imaginary beings of both sexes and human shape, who are fabled to frequent the haunts of men, to dance in meadows, and to be distinguished by a variety of fantastical actions, either innocent or mischievous. In traditions and romances they are frequently represented as beings of diminutive stature and exquisite beauty: and sometimes as women of an order superior to human nature, yet subject to wants, passions, accidents, and even death; sprightly and benevolent whilst young and handsome; morose, peevish, and malignant if ugly or in the decline of their beauty; generally robed in green, but fond also of appearing in white; from which circumstance they were sometimes called the White Ladies.

Concerning these imaginary beings, Jervaise of Tilleberry, marshal of the kingdom of Arles, who lived in the beginning of the thirteenth century, thus writes:—"It has been asserted by persons of unexceptionable credit, that fairies used to select lovers from among men, and rewarded their attachment with an affluence of worldly goods; but if they deserted them or revealed the connection, they smarted severely for such indiscretion." Similar tales were current in Languedoc; and throughout the province there was not a village without some ancient seat or cavern which had the honour of being a fairy's residence, or at least some spring in which a fairy used to lave its tiny form. This idea of fairies has a near affinity with that of the Greeks and Romans concerning the nymphs of the woods, mountains, and springs; and an ancient scholiast on Theocritus says, that "the nymphs are demons (spirits) which appear on the mountains in the figure of women." The Arabs and other orientals have also their *Peris*, of whom they entertain notions somewhat similar to those held in the west respecting fairies.

Fairies have usually been described as of small stature, though capable of assuming various forms and dimensions. It is scarcely necessary to add that the most charming representation of these children of romantic fancy is to be found in the *Midsummer Night's Dream*. For an elaborate account of fairies in general, see Keightley's *Fairy Mythology*, 2 vols. 8vo, in which the legends of different countries are collected.

Fairy of the Mine, an imaginary being, fabled to inhabit mines; wandering about the drifts and chambers, always employed in cutting ore, turning the windlass, &c., but effecting nothing. The Germans believed in two species; one fierce and malevolent, the other harmless. Such is the relation of Agricola, in his book *De Animantibus Subterraneis*.

Fairy Circle or Ring, a phenomenon pretty frequent in the fields, and supposed by the peasantry to have been traced by the fairies in their dances. There are two kinds of fairy ring: one of about seven yards in diameter, containing a round bare path, about a foot broad, with green grass in the middle of it; and another of different dimensions, encompassed with a circumference of grass. The formation of these rings was formerly ascribed to the action of lightning; and some have attributed them to the labours of ants; but Mr Cavallo, in his *Treatise on Electricity*, points to their true origin when he says—"They seem to be rather beds of mushrooms than the effects of lightning." These rings are seldom of a perfect form, and frequently spread with great irregularity, forming, as it were, a series of arcs of circles. This irregularity is occasioned by the peculiar mode of growth of the fungi by which they are produced. In the words of Dr Carpenter (*Principles of Physiology*), "The masses of fungous vegetation which form the progressively extending fairy rings or magic circles of the grassy meadow may be said to be several years of age, although, as fast as new tissue is generated on the exterior of the ring, that of the central side dies and decays, so that no individual part has more than a brief duration."

FAITH, that assent which we give to a proposition advanced by another, the truth of which we do not immediately perceive from our own reason or experience; or it is a judgment or assent of the mind, the motive of which is not so much any intrinsic evidence, as the authority or testimony of some other who reveals or relates it.

Faith, in *Theology*, denotes the assent of the mind or understanding to the truth of what God has revealed; or such a conviction of his being, perfections, character, and government, as produces love, trust, worship, obedience, and resignation. Faith in Christ, as it has been defined by some theologians, is a mere assent to the gospel as true; but according to others, it signifies such a persuasion that he is the Messiah, and such a desire and expectation of the

blessings which he has promised in his gospel to his sincere disciples, as engage the mind to fix its dependence upon him, and to subject itself to him in holy obedience. Faith likewise, in respect of futurity, is a moral principle, implying such a conviction of the reality and importance of a future state, as is sufficient to regulate the temper and conduct in the affairs of this life.

FAKENHAM-LANCASTER, a market-town and parish of England, county of Norfolk, on the banks of the Wensum, 24 miles N.W. of Norwich, and 109 miles from London. It formerly possessed a considerable trade in hand-made woollen goods, which, however, has gradually disappeared since the application of machinery to the manufacture of worsteds. The parish church is a very handsome edifice. The surrounding country is remarkable for its fertility, especially in wheat. Market-day, Thursday. Pop. of parish (1851) 2240.

FAKIR, an Arabic word, signifying "poor," which is employed to denote a kind of religious mendicant very common in India. In this sense it is synonymous with the Persian and Turkish dervise. A certain class of these mendicants live in communities like the monks of the Western world, while others live singly as hermits, or wander about making strange displays of self-torture and mortification. Although from time immemorial asceticism has been held in high veneration in the East, and it was deemed meritorious to retire from the world, to renounce the comforts of the domestic and social relations, and to live in poverty, solitude, and religious contemplation, the original principles of Mohammedanism were unfavourable to a monastic life. Religious mendicants did not appear among the Mussulmans till six centuries after Mohammed, in the thirteenth century of the Christian era. But there is reason to believe that they existed among the Hindus at a much earlier period. From the first they appear to have been distinguished by their ragged and filthy dress, and the severity of their self-inflicted penances. A celebrated member of their order, who flourished about the close of the twelfth century, says that the exterior of those devoted to a religious life should be a ragged dress and ill-combed hair; and a later writer affirms that a member of this mendicant order should have ten of the qualities proper to the dog,—to be always hungry—to have no fixed residence—to watch during the night—to leave no heritage after his death—not to abandon his master although ill treated by him—to content himself with the lowest place, and to yield his seat to any one who wants it—to return to the person who has beaten him when offered a morsel of bread—to keep at a distance when one is bringing him something to eat—and not to think of returning to the place he has quitted while following his master. Jâmi, the well-known Persian poet, in the introduction to his work on the lives of the Sûfis or Mohammedan mystics, divides those who seek the future into three classes,—the Zâhids, who, full of faith, look down with contempt upon the life on earth, which they consider as imperfect and miserable; the Fakirs, who renounce the world in the belief that their minds will by poverty be rendered fitter for the exercise of virtue, and that they will hereafter be recompensed for present privations; and the Abids, who hope to merit future reward by entirely devoting themselves to religious exercises. Among the Turks several orders of fakirs or dervishes exist. The chief of these is the order of the Maulavîs, founded about the close of the thirteenth century by the Persian poet Jelâleddin Rûmi. They have a great monastery at Galata and another at Iconium, and have also convents in nearly all Mohammedan countries. Mendicants of this order are notorious for their fondness of intoxicating liquors and of opium, and are addicted to the practice of sorcery, conjurations, and tricks of legerdemain. They may leave their order, and are then released from their vows of celibacy, and are permitted to marry. The order of the Rufûis are celebrated for their strange excesses of self-mortification. In their weekly meetings some of their number are always selected to hold a red-hot piece of iron between their teeth till it becomes cold, while the others make deep incisions in their bodies with sharp-edged instruments. A third class, termed the Calenders, are distinguished by the singularity of their dress. They sometimes wear a tiger's or a sheep's skin, sometimes garments made of party-coloured clothes, and not unfrequently go about half naked with their skin painted red or black, feathers in their ears, fancifully-shaped turbans or hats on their heads, a stick or a hatchet, or sometimes a drawn sword, in their hands, and in their girdles a plate or bowl, which they hold out to receive alms. In this guise they visit coffee-houses and other places of public resort to preach and to beg.

The Hindu fakirs go entirely naked, carrying on their shoulders a thick club, the end of which is wound round with rags of cloth of all colours. They strew their hair, which hangs half way down their back, with ashes, with which they sometimes besmear their whole bodies. Stavorinus says they generally take up their abode in shady places, either in the open air or in old and ruinous buildings, without using anything to repose on or to cover themselves. All classes of these mendicants endeavour to gain the veneration of the people by the infliction of absurd and cruel penances and tortures. Stavorinus says he met with some who, by holding an arm raised in one position for many years, had lost the power of lowering it again. Others had bent their bodies forward till they had grown so crooked that they formed a right angle. Some, by continually bending the head backward, could not bring it back to its natural position. Others keep the hands clasped together so long, that the nails grow into the flesh, and come out on the other side. Tavernier mentions that some of these fakirs never sit or lie down to sleep, but are supported by a rope hung down for that purpose. Others lay fire on their heads, and burn their scalps to the very bone. Others roll themselves naked on thorns. Some bury themselves in a pit or ditch for nine or ten days, without tasting food or drink. A recent traveller in India states that he saw a fakir who was never "known" to eat at all. He carried a small black stone about with him, which had been presented to his mother by a holy man. He pretended that by sucking this stone, and without the aid of any sort of nutriment, he had arrived at the mature age of forty in a state of obesity which did great credit to the fattening powers of the black stone. Oddly enough, his business was to solicit offerings of rice, milk, fish, and ghee, for the benefit of his patron, Devi. These offerings were nightly laid upon the altar before Devi, who was supposed to absorb them during the night, considerately leaving the fragments to be distributed among the poor of the parish. Sometimes, this writer adds, a fakir will take it into his head to trundle himself along like a cart wheel for a couple of hundred miles or so. He ties his wrists to his ankles; gets a *tire*, composed of chopped straw, mud, and cowdung, laid along the ridge of his backbone; a bamboo staff passed through the angle formed by his knees and elbows by way of axle, and off he goes; a brazen cup, with a bag, and a *hubble-bubble* hang like tassels at the two extremities of the axle. Thus accoutred, he often starts on a journey which will occupy him for several years. On arriving in the vicinity of a village, the whole population turn out to meet and escort him with due honours to the public well or tank, where he unbends and washes off the dust and dirt acquired by perambulating several miles of dusty road. After ascertaining, by minute inquiries, the state of the larders of the assembled villagers, he takes up his quarters with the man who is best able to entertain him. When the supplies begin to fail he ties his hands to his heels again, gets a fresh tire put on, and is escorted out of the village with the same formalities as accompanied his entrance.

Some of these mendicants are undoubtedly insane, but the greater part of them are impostors and hypocrites, who secretly indulge in the grossest licentiousness while they assume a sanctimonious air in order to obtain a pretext for idleness and for preying on the ignorant and superstitious natives. D'Herbelot estimated that there were 800,000 Mohammedan, and 1,200,000 Hindu, fakirs in India.

(D'Herbelot's *Bibliothèque Orientale;* Tavernier's *Travels;* Stavorinus' *Voyage to the East Indies; Household Words*, vol. iii., p. 310.) (J. T—R.)

FALAISE, a town of France, capital of a cognominal arrondissement in the department of Calvados, and situated on the right bank of the Ante, 21 miles S. by E. of Caen. Pop. (1851) 8700. It was formerly a place of some strength, and is still surrounded by old walls. The principal object of interest is the castle, now partly in ruins, but formerly the seat of the dukes of Normandy, and the birthplace of William the Conqueror. Falaise has two large and populous suburbs, one of which, Guibray, now rivals in size and importance the town itself, and is celebrated for its annual fair, which lasts from 10th to 25th August. The town contains a town-hall, hospital, theatre, several churches, and a public library. The manufactures are cotton goods, hosiery, leather, paper, &c.

FALASHA, a people of Abyssinia, described by Bruce, and supposed to be of Hebrew origin. According to their own tradition, they are descendants of Jews who came into Ethiopia as attendants of Menilek, the son of the queen of Sheba or Saba by Solomon. See ABYSSINIA.

FALCATED, in the form of a sickle: used more particularly of the moon when she appears in the form of a crescent or sickle.

FALCON (*Falco*), a name bestowed on several birds of prey, but chiefly on such as are trained to sport, as in hawking. See *Falconidæ* and *Falco* in index to ORNITHOLOGY.

FALCONER, WILLIAM, our greatest naval poet. Till now great uncertainty has prevailed in regard to the date of his birth, but in the parish records of the City of Edinburgh we find the following entry:—"11*th February* 1732.—William Falconer, wigmaker, and Agnes Shand had a son born named William." His father, a barber in the Netherbow, was unsuccessful in life, became bankrupt, and had two children besides the poet, both of whom were deaf and dumb. The old man, in his latter days, kept a small grocer's shop, but died in extreme poverty. The "young Arion" of the family was thus early inured to penury and distress. He received the scanty education required to qualify him for an inferior employment, and at an early age he was entered as an apprentice on board a merchant-vessel belonging to Leith. He afterwards served as a common sailor on board the ship of which Campbell, author of *Lexiphanes*, was purser, and attracted the notice of Mr Campbell by indications of talent. How long he continued in this humble capacity is not known; but by some friendly intervention he was appointed second mate of a vessel called the Britannia, employed in the Levant trade, which, however, was wrecked near Cape Colonna during her passage from Alexandria to Venice, and only three of the crew, including Falconer, were saved. This event suggested the idea of his poem, *The Shipwreck*, on which his reputation rests. But if Clarke be right in the opinion that he was the author of the fine naval song "Cease, rude Boreas," an exception must be made in favour of that popular lyric. Falconer continued in the merchant service until the spring of 1762, when he recommended himself to the notice of Edmund Duke of York, by the dedication of *The Shipwreck*, and enlisted his royal highness amongst the number of his admirers and patrons. Desirous to place him in a situation where he could be befriended, the duke advised him to enter the navy; and before the end of summer he was rated as midshipman on board the Royal George. But as this ship was paid off at the peace of 1763, and as Falconer's period of service had been far too short to enable him to obtain the commission of lieutenant, he was advised to exchange the military for the civil department of the navy; and, in the course of the same year, he received an appointment as purser of the Glory frigate, a situation which he held until that vessel was laid up in ordinary at Chatham. In 1764 he published a new edition of *The Shipwreck*, in 8vo, corrected and enlarged, most of the descriptive and episodical matter being introduced; and the following year appeared *The Demagogue*, a political satire, intended as a sort of antidote to the writings of Wilkes and Churchill, but much more remarkable for virulence than wit. His time, however, was chiefly occupied with the compilation of an *Universal Marine Dictionary*, a work much wanted, and which, when brought out in 1769, was received with general approbation. Before this period he appears to have left his retreat at Chatham for the metropolis; and Mr Murray, a bookseller, father of Byron's publisher and friend, wished him to join him in business. Falconer however declined, having received an appointment to the pursership of the Aurora frigate, which had been commissioned to carry out to India Messieurs Vansittart, Scroften, and Forde, as supervisors of the Company's affairs; and he was also promised the office of private secretary to these functionaries. The Aurora sailed from England on the 30th September 1769, and after touching at the Cape of Good Hope was never more heard of; she was supposed to have foundered in the Mozambique Channel.

Besides the productions already mentioned, Falconer was the author of several pieces, the most considerable of which are an Ode on the Duke of York's second departure from England as rear-admiral, and a Poem on the death of Frederick, Prince of Wales. His fame as a poet must, however, rest on *The Shipwreck*. There is a warmth in its colouring, and a reality in its descriptions, which, notwithstanding the didactic character of the poem, sustain its interest. Natural feeling, imagery, and truth are expressed in language which, if it never rises to a great elevation, seldom sinks below the dignity of the subject. Falconer does not aspire to produce a great effect by a few bold touches, or the rapid and masterly grouping of appalling or horrible circumstances. He labours in detail, bringing before us, without apparent effort, the events as they arise, and conducting us with an interest constantly increasing towards the catastrophe. He paints with minute fidelity as well as picturesque effect; but it is from the general result, rather than from any portion of the work considered separately, that the talents of the artist should be judged. Such a tremendous picture of shipwreck as that which Byron has, in wild sportiveness, thrown out in Don Juan, immeasurably transcends the powers of Falconer, and indeed stands alone in its terrible sublimity; but, on the other hand, the naval poet, by the careful elaboration of natural circumstances, and the general truth of his delineation, ultimately impresses the mind of the reader, if not with such vivid force, perhaps with even more enduring effect. Some of the classic invocations to the shores of Greece, and some descriptive passages, are a little tawdry, but the grand incidents of the poem dwell strongly on the recollection, and its impression is never forgotten. Nor are the technical expressions and directions a drawback to the general reader. They are explained in foot-notes, and give a truth and reality to the narrative; and they do not occur in the more impassioned scenes. (R. C—S.)

FALCONRY. See HAWKING.

FALERII (now *Santa Maria di Falleri*), in *Ancient Geography*, an ancient and powerful city of Etruria, believed to have been of Pelasgic origin; but in historic times it appears as an Etrurian city, and probably belonged to the Etrurian Confederation. Falerii was at first de-

cidedly hostile to the Roman name, and supported the Veientes in their war with that people, using their utmost efforts at the same time to rouse the other Etrurians to join them against the common foe. After the reduction of Veii the Faliscans saw themselves exposed to the full fury of the Roman arms; and after enduring a siege from Camillus, were obliged to surrender their capital into his hands. The interesting episode of the traitor schoolmaster and the generosity of the Roman commander need only be hinted at to be generally remembered. From this time Falerii continued, sometimes at peace, sometimes at war, with Rome, till at the close of the first Punic war it rose in open rebellion; but after a short resistance it was taken and destroyed, and the inhabitants were forced to select a site for a new town in a less inaccessible position than the old city had occupied. In the middle ages, however, the inhabitants, invited by the impregnable position of the old site, returned to it and built the town now known as Civita Castellana. The ruins of the second or Roman Falerii are now occupied by the small hamlet of Sta Maria di Falleri.

FALERNUS AGER, a district in the northern part of Campania, celebrated for its wine, which in the time of Horace was reputed the best of all the Italian wines. It included the country extending from the Massic Hills to the river Vulturnus; and when it passed into the hands of the Romans in 340 B.C., formed part of the Capuan territory. The Falernian wine so famous in the times of Horace had began to degenerate before those of Pliny, in consequence of careless cultivation; and were supplanted in general estimation by those produced in the adjoining Ager Statanus.

FALKIRK, a municipal and parliamentary burgh and market-town of Scotland, county of Stirling, beautifully situated on the face of an eminence which overlooks the wide expanse of fertile country called the Carse of Falkirk. The town consists of one wide street, with a number of narrow streets and lanes branching off from or running parallel to it. The houses are generally lofty and well built. The parish church, erected in 1811, has a fine steeple 130 feet high. There are also places of worship for the Free Church, United Presbyterians, Independents, and Roman Catholics. There is also a flourishing school of arts in which lectures on scientific subjects are delivered every winter. Continuous lines of houses connect Falkirk with the villages of Grahamston and Bainsford, and extend thence to Carron, which lies about 2 miles N. of the town, and is celebrated for its iron-works. Though Falkirk is not itself a manufacturing town, having only some tanneries, breweries, and a small manufactory of pyroligneous acid, yet the neighbourhood teems with extensive works of various kinds. In addition to the Carron iron-works there is the Falkirk foundry at Bainsford, employing about 500 persons; besides several extensive collieries, distilleries, flour-mills, &c. The three trysts or cattle fairs held here annually, on the 2d Tuesday of August, and the 2d Monday of September and October, are the largest in Scotland; the last being by far the largest of the three. Each continues for at least two days, and sometimes for nearly a week. Falkirk is a town of considerable antiquity, and appears to have been a place of some note in the early part of the eleventh century. Its original name was Eglishbreckk, which signifies the "speckled church," in allusion it is supposed to the colour of the stones, and translated by Buchanan *varium sacellum*. The old church demolished in 1810, and whose site is occupied by the modern edifice, was erected in 1057, the year in which Malcolm Ceanmore assumed the sovereignty. In the valley between Falkirk and the Carron a battle was fought between the Scotch under Sir William Wallace and the English under Edward I., in which the former were defeated, and two of their chieftains, Sir John Graham and Sir John Cumming, slain. Their graves are still pointed out in the churchyard: that of Graham has a monument with an inscription which has been several times renewed. On a moor a little to the S.W. of the town a battle was fought on 17th January 1746, between the royal forces and those of the Pretender, in which the rebels were victorious. On this occasion fell Sir Robert Monro of Foulis, and his brother Dr Monro, whose monument is to be seen in the churchyard. In the vicinity traces of the Roman wall are still visible. Falkirk was formerly a burgh of barony, but was created a royal parliamentary burgh by the Reform Act, and is now governed by a provost, 3 bailies, a treasurer, and 7 councillors. It unites with Airdrie, Lanark, Hamilton, and Linlithgow, in returning a member to parliament. Pop. (1851) 8752. It is 24 miles W.N.W. of Edinburgh, on the Edinburgh and Glasgow, and the Scottish Central railways.

FALKLAND, a royal burgh of Scotland, county of Fife, at the N. foot of the East Lomond Hill, 22 miles N.N.W. of Edinburgh. Pop. (1851) 1330. It consists of a single street with some cross lanes; the houses being in many cases thatched and of an antique and primitive appearance. Falkland is a place of little or no traffic, and the inhabitants are mostly engaged in weaving. It is chiefly noted for its royal palace, originally a stronghold of the Macduffs, earls of Fife, but forfeited to the crown in 1424 on the attainder of Mordac Stewart the 17th earl. It was greatly enlarged and improved by James V., who died here in 1542; and was also the favourite residence of James VI., on account of the fine park and abundance of deer. The east side was accidentally burnt in the reign of Charles II., and the park ruined during the time of Cromwell, when the fine oaks were cut down in order to build a fort at Perth. In 1715 the famous Rob Roy garrisoned the palace and laid the burgh and vicinity under contribution. The palace till recently was allowed to fall into decay, but what remained of it has been renovated and fitted up, and now forms the residence of O. T. Bruce, Esq., the heritable keeper. Falkland was constituted a royal burgh by James II. in 1458, and its charter was renewed by James VI. in 1595.

FALKLAND ISLANDS (French *Malouines*, Spanish *Malvinas*), a group of islands in the South Atlantic Ocean, belonging to Britain, and lying about 250 miles E. of the nearest mainland of South America, between 51. and 53. S. Lat., and 57. and 62. W. Long., or in precisely the same latitudes south as London and the midland counties are north. The group consists of two principal islands, East and West Falkland, with several hundred others of different sizes clustered around and in the strait between them. East Falkland is about 85 miles in length by 40 in breadth, and West Falkland 80 miles long by 25 to 30 miles wide. They are separated from each other by Falkland Sound. The other islands range in size from 16 miles by 8, to mere islets of half a mile across. The whole group is deeply indented by numerous harbours and creeks, which, if they diminish the area, produce more than counterbalancing advantages. Very little is known of West Falkland. It is uninhabited, but at certain seasons is visited by whaling and other vessels. East Falkland is nearly divided into two unequal portions by the estuaries called Breton Sound and Choiseul Sound, the two parts of the island being connected by an isthmus not more than a mile and a half across. The northern portion is crossed by a chain of rugged hills, called the Wickham Heights, extending due E. and W., from Port William to Port Sussex, and varying in height from 800 to 2000 feet. This range consists chiefly of quartz rock, which crops out with great irregularity, so that it can be crossed only at certain passes. South of this range it is one continued undulating plain, few of the heights rising to more than 60 feet above the level of the sea, and the ridges running nearly N.W. and S.E. Through every little valley a stream of fresh water flows into one or other of the numerous creeks and inlets of the sea. Besides these rivulets, there are numerous

fresh-water ponds or lakes, varying from 30 yards to 3 or 4 miles in circumference. North of the Wickham Heights the surface is hilly, some of its elevations rising to the height of upwards of 1000 feet. The side of the heights contains slate, some of which is suitable for building and roofing purposes; and limestone has been discovered on and about the foot of Mount Usborne. From certain parts of these upper regions there descend into the valleys *streams of stones*, from 20 or 30 feet to a quarter of a mile wide, and below these stones there usually flows a stream of water. These stones are frequently of considerable size, and have not moved far, as their angles are generally but little broken. The climate is said to be very mild and salubrious. The temperature is more equable than that of England, being rarely so hot in summer or so cold in winter. The ice is seldom more than half an inch thick, except in very severe winters, and snow lies but a short time on the ground. Light showers are frequent, but a day of heavy rain never occurs. Excessive winds are common, but thunder-storms are extremely rare. The hottest months in the year are December and January. The soil is of a deep brown, almost black, compact, peaty quality, lying upon a strong clay subsoil, and from 6 inches to 2 feet deep. North of the Wickham Heights the soil is lighter, more peaty, rank, and on an inferior subsoil (a red gravelly clay), and in the neighbourhood of the quartz rock formations, on a stiff dirty-white clay.

There are few wild animals indigenous to the Falklands. The only quadruped is the warrah or wolf-fox (*Canis Magellanicus*), rather taller, but not much heavier, than our fox. The other animals which are found in a wild state are those which have been left there by Europeans, as horned cattle, horses, sheep, wild hogs, and rabbits, all of which are very abundant. There is a plentiful supply of excellent fish in all the creeks, and of small trout in the lakes and rivulets. Hair and fur seals abound, and the black whale is still numerous about these coasts. The wild fowl are also numerous, as swans, geese, ducks, snipes, &c. There are few land birds or insects, and no reptiles.

A gigantic sedgy grass, called tussac, of the genus Carex, is very common on most of these islands. Its blade averages seven feet in length by about three-quarters of an inch in width, is extremely nutritious, and admirably adapted for fattening cattle. Turnips, carrots, potatoes, and vegetables thrive well, and barley and oats have been successfully cultivated. Furze and other shrubs grow well, but there are as yet no trees. Peat is abundant, and some of it is highly bituminous. Coal has been discovered, but whether it can be profitably worked has not yet been ascertained.

The discovery of these islands has been by many attributed to Amerigo Vespucci, in 1502; but it is more probable that they were first discovered by Davis in 1592. In 1594 Hawkins sailed along their north shore; and in 1690 Strong sailed through the channel which separates East from West Falkland, and called it Falkland Sound, whence the group afterwards took its name. During the earlier parts of the eighteenth century these islands were frequently visited by French vessels; and in 1764 a French colony was established at St Louis, on East Falkland. Two years later the English planted a colony at Port Egmonton, West Falkland. In 1767 the Spaniards took possession of the French settlement, and three years later of the English. In consequence of this step, some negotiations were entered into, the result of which was that the sovereignty of these islands was ceded to the English, who, however, some time afterwards abandoned them. Though frequently visited by whaling vessels and others, they continued without permanent inhabitants till 1820, when they were taken possession of by the republic of Buenos Ayres. A settlement was formed at Port Louis, which rapidly increased until 1831, when, in consequence of a dispute with the United States, it was destroyed by the Americans. In 1833 the English again assumed possession of the Falklands, and stationed an officer and boat's crew at Port Louis. In 1840 the government resolved to colonize these islands, and sent out for that purpose a governor and a small establishment, who settled at Port Louis. A more advantageous situation for a settlement was subsequently found on the south side of Stanley Harbour, where, in 1844, a town was laid out. Mr Lafone, a wealthy merchant, obtained from government an extensive tract of land, and possession of all the wild cattle and other wild stock for six years, from 1st January 1848, in consideration of a payment by instalments of L.60,000. Mr Lafone's interests have recently been purchased by a chartered company, which now possesses, in East Falkland, all the southern peninsula called Lafonia, consisting of about 600,000 acres besides 138 islands and islets, with an aggregate area of about 200,000 acres, until January 1856. The company possesses absolute right to all the wild cattle or other wild stock which may be found upon any of the islands, but after that period this right ceases except as to stock, &c., then in actual possession of the company. In 1847 the population of the colony was 270. The governor of these islands, in January 1853, reports the colony to be steadily progressing. In 1851, the number of tons of shipping that entered the port of Stanley was 17,538, and in 1852 it was 22,024, being an increase of 4,486 tons. This necessarily produces a demand for produce and labour. Unskilled labourers earn from 3s. to 5s. a day, and skilled from 6s. to 10s. Provisions are abundant, and at reasonable prices. "The transference to the Falkland Islands Company of the large interests held by Mr Lafone, and the commencement by that corporation of a more comprehensive system of operation, supported by a large capital, gives me very favourable hopes of benefit to the colony, and, I trust, to the shareholders." (*Report.*) In 1849, twelve allotments of one acre each, near the town, were put up for sale, and were sold on an average at L.6 per acre; and eleven similar allotments, sold in 1852, brought on an average L.12 per acre, or six times the usual government price. "The master of a barque, the Record, lately in the harbour, publicly notified that he would take passengers to the gold diggings in Australia at L.10 per head, and it gives me much pleasure to add that not a person could be found in the colony to accept his proposition." (*Report.*) Being chiefly dependent upon the ships that call here to refit or for refreshments, the opening of a ship canal between the Atlantic and Pacific Oceans would affect this settlement very much, and might probably lead to its abandonment.

FALL, the name given in Scotland to a measure both of length and superficies. As a measure of length, the fall is equal to six Scots ells, or 6·1764 English yards; and as a measure of superficies, to 36 square ells.

FALL OF MAN, in sacred history, that memorable event by which man lost those perfections bestowed on him by his Maker at his creation. See THEOLOGY.

FALL RIVER, a town of the United States, Massachusetts, 46 miles S. of Boston, situated on the Fall River, at its junction with the Taunton, which last falls into Mount Hope Bay, a branch of Narraganset Bay. The harbour on Taunton river is safe and easy of access, and has depth of water sufficient for the largest ships. Fall River has a large coasting trade, and is engaged in the whale and other fisheries. It has extensive cotton and woollen factories, bleaching works, foundries, &c., and communicates regularly with New York by steamers, and with Boston by railway. Pop. (1850) 11,522.

FALLACY is a logical term; but in the consideration of the ideas denoted by it, we are led, at several points, beyond the ground occupied by Logic Proper. Especially there is often involved, in the scrutiny of fallacies, examina-

tion of the matter of arguments, that is, of the nature of the objects argued about. The chapters on fallacies, therefore, which appear as appendices in the most elaborate logical treatises, really travel more or less out of the proper domain of the science; and the topic may here deserve a few paragraphs of separate illustration.

A Fallacy is an unsound or inconclusive argument; an argument supposed or alleged to prove a conclusion which it does not prove. The name is sometimes confined to sophisms, that is, unsound arguments used with the intention to deceive. But the intention is a point of secondary importance in the theory of fallacies; and, indeed, those fallacies in which the reasoner deceives himself are by far more dangerous than the others, because they are by far more common. The term Fallacy, it will thus be observed, is applicable to an argument taken as a whole, not to any of the propositions of which the argument is composed. The propositions severally must be true or false: the argument which they constitute must be correct or fallacious; that is, its conclusion must either follow or not follow from the premises.

In demonstrative reasoning, such as that whose matter is mathematical truth, there is but slight occasion for a systematic consideration of fallacies. The ideas which arguments of this sort deal with are both few and simple; and the words in which the ideas are expressed have precise and well-fixed meanings. But in probable reasoning, the matter of which comprehends all questions directly regarding human character, and conduct, and destiny, the ideas are many and complex, and the language is seldom either precise or exactly defined. In testing such an argument, therefore, we have to begin by subjecting it to something like an anatomical dissection. We aim at exhibiting the bare skeleton of the argument, that we may be able to perceive whether its parts are or are not firmly knit together.

The process by which we gain such a view of an argument is twofold. There is required, on the one hand, a stripping off of everything inessential. Into every argument in probable matter, much that is inessential finds its way even in thought; and still more that is inessential intrudes into the argument when it passes into words. It is required, on the other hand, to bring distinctly into view all the points of junction—all the points at which one part of the argument is related to another. In the form which argumentation naturally and usually assumes, all those points are not exposed. We have, and we continually indulge, a tendency to argue elliptically, to omit steps of our reasoning; and, omitting largely in thought, we omit still more largely in expression. The honest thinker passes over hastily in his own mind, and denotes but briefly, if at all, in words, those steps as to which he himself has no doubt, and which he believes to be equally clear to others: the sophistical debater slurs over, or keeps back altogether, if it be possible, those steps in which he knows the weakness of his argument to lie.

In a word, paradoxical though the assertion may appear, it is found, when we aim at testing our ordinary acts of reasoning in probable matter, that they are irregular both by excess and by defect. The testing of the arguments by the laws of the syllogism is very easy, as soon as those faults have been cured. The difficulty lies in the process of cure, that is, in the analysis of the argument, and the exhibition of it in its naked form. Further, the two parts of the cure are not equally difficult: the least so by far is the weeding out of the superfluities. The filling up of the gaps is often a very troublesome task. Indeed, when a chain of argumentation is very long and complex, it very frequently—whether through looseness of thinking, or through the design to mislead—deviates so widely from regularity of form, as to admit, and often at more points than one, of being filled up in any of several alternative ways. In such an instance, we are almost certainly safe in believing that the reasoning is fallacious; and it will almost always be possible to indicate two or more specific fallacies, one or another of which must have been committed. Such a position—satisfactory where a man wishes sincerely to estimate the accuracy of his own reasonings—is not so strong as might be wished when we endeavour either to convince a candid but confused disputant of error, or to expose sophisms committed by disputants who are not candid. Another case, which is often still more annoying, while it is also more common, is that in which one and the same argument is found to involve more fallacies than one; a case which is made particularly frequent by this, that almost every fallacious argument which is really troublesome owes its force, in a greater or less degree, to its introduction of ambiguous terms.

For dealing efficiently with serious difficulties of the kind, we require two qualifications. The first is exact knowledge of the syllogistic laws, with readiness and correctness in the use of them. The second is familiar acquaintance, and aptness in the use of our acquaintance, with the various forms of fallacy, or methods of incorrect reasoning. Towards the attainment of the latter of the two, the fuller and more accurate of the treatises on logic aim at giving assistance in their supplementary consideration of fallacies. A complete enumeration and classification of fallacies has not been achieved by any of the logicians, and is indeed impossible; but those which are most common and most dangerous may be and have been identified and described, and arranged according to several different principles, each of which has its uses in particular applications.

There has been a general agreement in accepting, as the first step in the classification of fallacies, the Aristotelian division of all of them into two classes: Fallacies *in Dictione* (παρα την λεξιν); Fallacies *extra Dictionem* (εξω της λεξεως). The former are otherwise describable as Formal or Logical Fallacies, as errors in the process of reasoning itself; the latter as Material or Non-Logical Fallacies, as errors arising beyond the reasoning process. The distinction thus indicated is perfectly sound; but the application of it is difficult, and the distinction itself sometimes evaporates in the attempt to apply it. Fallacies referred to the second class by some logicians are placed in the first by others; and by some of the schoolmen (Occam for one) it has been maintained, that the Aristotelian classes are not separated by a distinction really identical at all points with the distinction between fallacies formal and fallacies material (*a parte vocis* and *a parte rei*). The details, accordingly, have been worked out variously by different writers; none of the elaborations perhaps being so useful as that of Archbishop Whately, which exhibits the author's usual success in dealing with questions having a close practical bearing. Whately's distribution and description of fallacies will, with other authorities, furnish much to the hasty outline here to be given. There may advantageously be compared with it Mr Mill's classification, which is specially designed for bringing out the forms which error is most likely to assume when reasoning is used in the process of scientific discovery. Some other recent treatises on fallacies aim at exemplifying the application of fallacious reasoning in other special departments of thought. Thus Bentham's *Book of Fallacies* may be described as showing, how certain wrong rules of judgment in political questions may be referred to the several kinds of fallacy, and most easily detected. Comte's discussion of fallacies embraces only an incidental denunciation of certain prevalent opinions, which stand in the way of his Positive Philosophy.

I. Perhaps our path may most readily be cleared, if, first of all, we regard Fallacies as distributable into Three Classes. They are either Fallacies of Assumption, Fallacies of Exposition, or Fallacies of Inference.

II. For the detection of Fallacies of Assumption, logic cannot afford any direct assistance. It can aid us only through the training it gives us in clearness of thought, and in sub-

tlety and dexterity of analysis. The error of Assumption consists in our reasoning from premises which are either untrue in themselves, or not admitted by those whom we wish to convince. The unwarranted assumption may take place in either of two ways. (1.) The more common of the two was comprehended by the Aristotelians in their second class of fallacies: it was called *petitio principii* or *quæsiti*, and is familiarly known to us as the "Begging of the Question." It consists in taking for granted the thing to be proved. We assume a premise, which either is identical with our conclusion, or (more frequently because more availably) is so far dependent on our conclusion that it cannot be held as established till the conclusion is admitted. That which is strictly denoted by "Reasoning in a Circle" is the use of two arguments of this kind, in the second of which, assuming the conclusion of the first, we thus try to prove the premise which in the first we had wrongly assumed. A genuine and complete instance of reasoning in a circle is a rare incident. (2.) The second kind of the fallacy of assumption, embraces all cases of wrong assumption not resolvable into the begging of the question. Evidently its possible varieties are innumerable. In our own reasonings, we may be tempted to assume an untrue premise by any circumstance which makes our knowledge imperfect or erroneous; in attempting honestly to convince others, we may use a premise unadmitted by them, whenever it happens that we are incompletely informed as to the state of their belief in regard to the question argued about. For the sophistical use of the fallacy, occasion may be furnished by circumstances of either kind.

III. When a fallacy of assumption has occurred, the argument is of course unconvincing, even though no error has been committed in the process of inference. So is it likewise when the fallacy is a Fallacy of Exposition. The word "relevant" and its cognates have been branded as Scotticisms: but they are extremely convenient; and in this application they are adopted by Whately. Placing this kind of paralogism among the fallacies of matter, he aptly translates its scholastic name "ignoratio elenchi" by the phrase "Irrelevant Conclusion." The Latin name bears reference to the case of disputation: the disputant who uses the fallacy is said not to know, or to profess not to know, the "elenchus," that is, the proposition which, as being the contradictory of his opponent's conclusion, it was his duty to prove. The fallacy is committed when the conclusion which we infer, although it may be legitimately deduced from premises true or admitted, is not the conclusion we were bound to prove. We denounce such a fallacy when we say, "that is not the point," or "that is not the question."

When the error is described as a Fallacy of Exposition, the feature intended to be brought into view is this; that it consists essentially in a mis-statement or wrong exposition of the question argued. Its varieties are indefinitely various: it has correctly been said that no fallacy has so wide a range as this. It is always, in one shape or another, referable to the case which is usually set down as one of its specific kinds, namely, that which is spoken of as a "shifting of the ground." Under such names as this, it is especially familiar to lawyers, and not very rare in controversies ecclesiastical and theological. Several kinds of it, which shift the ground of argument in certain specific directions, have received specific names. One such is the "Argumentum ad Hominem," when it is used fallaciously (sometimes this argument is quite legitimate); all such arguments as those which seek to challenge a conclusion, not on its own merits, but on the score of inconsistency on the part of the person maintaining it. Another is the "Argumentum ad Verecundiam," the appeal to authority; which evidently may in some kinds of questions be really an impregnable argument, while still oftener it may fairly avail for securing a suspension of judgment; but which still oftener is used illegitimately, and must always be so when the matter is of a kind in which independent thinking ought to rule. To this kind belong also all attempts (in the popular phrase) to Move the Passions; all attempts to bias the judgment through emotion, desire, or aversion, when the question is one which should be decided on grounds purely intellectual. Under this head also may most conveniently be placed all such errors as we commit, when we hold a conclusion as *dis*proved when it has merely been *un*proved; or when we treat the use of any of the last-named kinds of argument as fallacious and inapplicable to the case, the case being one in which they are legitimately applicable.

It may appear to some, that Fallacies of Exposition ought to be considered as being nothing else than a particular kind of fallacies of assumption. It is, in fact, a point carefully to be observed, that they come into play only through the unwarranted assumption of a premise or premises in the last step of the reasoning, the step which leads directly to that which is represented as the conclusion. But they are peculiar in this: that, whereas in proper fallacies of assumption there may be, and often is, a shifting of premises, there is not there, and is here, a shifting of conclusion. Altogether, the fallacies of exposition seem entitled to the middle place here given them; a place which intimates their alliance on the one side to the fallacies of assumption, and on the other to the fallacies of inferences, while it denotes also that they are essentially distinguishable from both. Here, as in fallacies of assumption, logic does not directly help us; but here, as in fallacies of inferences, the conclusion wanted is not proved.

IV. All fallacies rightly referable to the two classes hitherto described would fall, in the scholastic scheme, within the class of Fallacies *extra dictionem*. Fallacies of the Third Class above named, those of Inference, are all of them Fallacies *in dictione*.

In these a logical error has place. The conclusion which the argument is supposed or alleged to prove, does not follow from the premises. Therefore, such a fallacy is effectually exposed, as soon as the argument containing it has been resolved into the form of a syllogism. A pretended argument, doubtless, may have in it so little even of the resemblance of reasoning, that its resolution into the syllogistic form is impossible; and in such a case the varieties of possible error are indefinitely numerous: but no such case is worth considering, since none such could for a moment mislead any rational being. Again, where the argument is so like a genuine act of reasoning as to be resolvable into the syllogistic form, there are some of the syllogistic rules (such as those for negatives) which cannot have been violated. Accordingly, all the Fallacies of Inference that require enumeration are four: Illicit Process, either of the Major Term or of the Minor; Non-Distribution of the Middle Term; and the occurrence of More Terms than Three. The last of these fallacies is found, on a strict analysis, to comprehend the other three: all of these are just specific instances of it. In a legitimate act of reasoning, we use three terms and three only, comparing each of these once with each of the other two. Every logical error consists really in the introduction of a fourth term, which carries with it the want of one of our three comparisons. The fallacy may be, our having either two major terms, two minors, or two middles. This doctrine is worth remembering, because of its bearing on that kind of logical fallacy which is practically most important.

A distinction now presents itself, separating Fallacies of Inference into Two well-marked Genera. First, the fallacy may appear on the face of the argument: it may be evident before we have considered the meaning of the terms, or when (as in the use of the symbolic terms so common in logical examples and essential in algebra) none of the terms has any appropriated meaning. Secondly, the fallacy may

not appear until we have ascertained, by interpretation, the meaning of the term in which it occurs. Fallacies of the first kind have been called Purely Logical Fallacies, those of the second kind Semi-Logical. The names are justly applied; for interpretation of terms is not a function of logic, and fallacies of the second kind are not cognisable by logical tests until the process of interpretation has been performed.

(1.) The Fallacies Purely Logical are not named by Aristotle among the thirteen kinds into which he distributes all fallacies; and they receive little attention, oftenest none at all, in the special discussions on fallacies by the schoolmen. The reason is plain. The systematic doctrines of the syllogism, taught in preceding parts of the logical treatises, were supposed to have furnished, for the detection of these fallacies, all the aid that is either attainable or needful. They should be at least named, however, in any scheme professing to enumerate the possible kinds of fallacies; and it is questionable whether they do not deserve, in modern times, a larger share of attention than that which may once have sufficed for them. "We live," says Mr De Morgan, "in an age in which formal logic has long been nearly banished from education—entirely, we may say, from the education of the habits. . . . . Offences against the laws of syllogism (which are all laws of common sense) are as common as any species of fallacy; not that they are always offences in the speaker's or writer's mind, but that they frequently originate in his attempt to speak his mind. And the excuse is, that he meant differently from what he said; which is received because no one can throw the first stone at it; but which in the middle ages would have been regarded as a plea of guilty." Even for the applicabilities of the syllogistic tests to the argumentative section of our common affairs, notice is merited by the hint here involved, of the intimate relation between the fallacies purely logical, and those others (avowedly very frequent) which we speak of as semi-logical. Of the close bearing of the theory of the syllogism on the theory of scientific discovery, proof will be found by any one who glances at Mr Mill's treatise on Fallacies, in his great logical work.

(2.) All the Semi-Logical fallacies of inference are referable to one cause, Ambiguity of Terms. Two remarks are here necessary. In the first place, we must understand distinctly what the logicians mean, when they say that a syllogism is fallacious because one of its terms is ambiguous. Every term we can use, every single word, and, far more clearly, every combination of words, is ambiguous in this sense, that it is susceptible of more meanings than one; but when the use of an ambiguous term is said to be the source of a fallacy, what is signified is, that, each of the three terms of an argument occurring twice in it, the term in question is actually used in one of its meanings on its first appearance, and in another on its second. That every phrase or word is capable of being so used, is a fact which shows how extensive is the risk we run of committing the Fallacy of Ambiguity. In the ordinary and familiar uses of argumentation, where we employ words whose significations are fixed only by custom and tacit convention, our liability to the error is proportional to the closeness of relation between two meanings of any given word or phrase, *plus* the probability that both of the meanings will suggest themselves to us or to others in the course of a given argument. In philosophical and scientific discussions, there is no effectual protection against mistakes thus arising, unless by the precedent definition of every term that is to be used; a precaution which, notoriously, is not fully attainable anywhere except in the pure mathematics. Secondly, the books on logic are nearly unanimous in describing the ambiguity that causes fallacy, as occurring in the middle term only: the fallacy is called that of "ambiguous middle," even by writers who explicitly allow that this is not the only possible instance. It is true that the middle term is much oftener used in two meanings than is either of the other terms; chiefly because, not emerging in the conclusion of an argument, it is by much the least prominent of the three. But undoubtedly the fallacious double meaning is to be found sometimes in the major term or in the minor.

It is plain that, when the Fallacy of Ambiguity is committed, the argument has really more terms than three. It is only in appearance that a term used in two meanings is one term: it is really two terms; it is one term in the one of its meanings, and a different term in the other. It is equally plain that, in one or another of its forms, this is the most common, and also the most dangerous, of all instruments that effect either mistake or deception. It is, as was asserted a little ago, the most frequent ally of fallacies of the other kinds; which, when the case does not lay open a firm enough foundation for them to occupy alone, gain support by their union with a convenient ambiguity. But the fallacy is so tempting, through the manifold imperfections of language as the vehicle of thought, that, even without foreign aid, it is continually productive of error. It is the curse of all those sciences which have human nature as their object-matter, especially of those higher and more analytic ones which, in the incorrect phraseology of common use, are often slumped together by the name of metaphysics. Its effects are not less injurious, when the communication of belief is aimed at through that which we speak of as eloquence, whether oral or written. The loose and inconclusive declamation, both of sophistry and of imperfect knowledge, gains a hearing through its adoption of one name to denote two things substantially different; and, in applications less extensive, but not less serious, truth is obscured, or positive error substituted for it, by the eagerness of cultivated writers to attain what they regard as elegance of style, for which, in our day, one of the favourite prescriptions is a needless variation of phrase.

The shapes assumed by the Fallacy of Ambiguity must clearly be so diverse, as to baffle all attempts at classification, or even enumeration. The ambiguity which is caused by the construction of clauses (the amphiboly or amphilogy of the old writers) is probably less frequent than that (the homonymy of Aristotle) which is caused by the double meaning of a single word or term. The Homonymy, or ambiguity strictly so called, arises out of something in the term itself; and the sources of it might be shown to embrace all those relations of things which, when used in an opposite direction, give rise to tropes and figures of speech. Several varieties of ambiguity spring from the particular way in which the term is applied on the particular occasion. Of these, the most nearly akin to the homonymy (and rightly transferred by Whately from the class of material fallacies) are the "Fallacia a dicto simpliciter ad dictum secundum quid;" and the counter-fallacy, called also the "Fallacia accidentis." In each of these, a term is used absolutely in the one of its appearances, and with a qualification in the other. If, from assuming as to the term taken absolutely, we infer in regard to it as qualified, the fallacy is of the first kind; if we infer the other way, it belongs to the second. Like to this pair in several respects are the counter-fallacies of Composition and Division. In the fallacy to which the former of these names is strictly applicable, we assume that something is true of a common term taken distributively, or, in other words, that something is true of each of the individuals comprehended under the term; and we thence infer to the term taken collectively, that is, to the aggregate of those individuals. In the counter-fallacy the process is reversed. The principle of the two fallacies last described affords also the easiest means of exposing many fallacies, in which the form of the argument does not directly present the antithesis of collection and distribution, and which, accordingly, might be placed under other heads, and analysed by a different method.

The heads thus named are very far indeed from presenting an exhaustive list even of the principal Fallacies of Ambiguity. It is the fact, indeed, that a vast proportion of the errors in reasoning by which we are perplexed or seduced, are referable, in the first instance, to that wide class which Mr Mill calls Fallacies of Confusion: the main reason of the fact lies in the frequency with which double meanings insinuate themselves into acts of ratiocination; and, when we are at a loss to determine the class to which an argument evidently fallacious may most properly be referred, and are consequently doubtful as to the best method of exposing it, a rigorous analysis will probably show that the difficulty is caused by some deeply lurking fallacy of ambiguity. (W. S.)

FALLING SICKNESS. See EPILEPSY.

FALLING or SHOOTING STAR, a luminous meteor which appears suddenly darting through the air. Falling stars occur at all seasons, but most frequently in the latter part of autumn, especially during the prevalence of the aurora borealis, and most commonly in the lower regions of the atmosphere. These phenomena are now generally supposed to depend on electricity.

Sir Humphrey Davy, however, in a lecture delivered at the Royal Institution, gave many reasons against this theory; conceiving that they are rather to be attributed to falling stones. It may also be mentioned that Chladni, in his work on Fiery Meteors (Vienna 1819), considers them as solid bodies formed above the regions of our atmosphere, and classes them with aërolites. Some consider them as extreme portions of the zodiacal light occasionally crossing the earth's orbit. It has been observed that when falling stars appear in great numbers, the direction of their course is similar. See ELECTRICITY, and METEOROLITE.

FALLOPIAN TUBES, in *Anatomy*, two ducts arising from the womb, one on each side of the fundus, and thence extending to the ovaria. They are called *tubæ* from their form, which bears some resemblance to a trumpet; and derive their denomination of Fallopian from Gabriel Fallopius, who was the first to indicate their use and office.

FALLOPPIO, GABRIELLO, in Latin FALLOPIUS, one of three anatomists to whom Cuvier assigns the honour of having restored, if not actually created, their science; Vesalius and Eustachius being the other two. He was a native of Modena, and though the year of his birth is not accurately known, it may be assigned to the end of the first quarter of the seventeenth century. He received his medical education at Ferrara, and in that city he established himself as a teacher of anatomy, after completing a scientific tour through the most civilized portions of Europe. From Ferrara he removed to Pisa, attracted thither by the liberal offers of Cosmo I. Grand Duke of Tuscany, and from Pisa to Padua, where the Venetian Senate appointed him to succeed Vesalius. His career in his new sphere, though brilliant, was short, as he died in 1562, after holding his various appointments for only eleven years. His only work, the *Observationes Anatomicæ*, was first published at Venice in 1561, and has been frequently reprinted. For an account of the services which Fallopius rendered to anatomical science, see art. ANATOMY, vol. ii., p. 759.

FALMOUTH, a municipal and parliamentary borough and market-town of England, county of Cornwall, on the S. side of Falmouth Harbour, 15 miles N.N.E. of Lizard Point, and 267 miles S.S.W. of London. It is governed by a mayor, 4 aldermen, and 12 councillors, and in conjunction with Penryn, about 2 miles distant, returns 2 members to parliament. Pop. (1851) of town 4953; of the parliamentary borough of Falmouth and Penryn 13,656; registered electors 906. In the early part of the seventeenth century Falmouth consisted only of a few fishermen's huts, but soon after this Sir John Killegrew, having obtained the permission of James I., constructed a new quay and laid the foundation of the present town. Its subsequent prosperity was a consequence of the excellence of its harbour, and its proximity to Land's End. For about 150 years it was the port from which the mail packets for the Mediterranean, Spain, the West Indies, and South America, were despatched, but it is now for the most part superseded by Southampton. The harbour is one of the best refuges for shipping in England. Its entrance, between St Anthony's Head on the E. and Pendennis Castle on the W., is about a mile in width, and it thence stretches inland about five and a half miles. It has depth of water and excellent anchorage for the largest ships, and vessels of considerable burden can discharge their cargoes at the quay. The number of vessels registered as belonging to the port on 31st Dec. 1853 was 124 vessels of 8771 tons burden. The number that entered and cleared at the port during 1853 was as follows:—coasting trade, inwards, sailing vessels 710, tonnage 40,271; steam vessels 141, tonnage 29,447; outwards, sailing vessels 215, tonnage 9195; steam vessels 75, tonnage 7151: Colonial and foreign trade, sailing vessels, inwards, 161, tonnage 13,379; outwards, 147, tonnage 17,934. The exports include copper, tin, tin-plates, woollen goods, pilchards and other fish, &c., and a considerable coasting trade is carried on with London, Plymouth, Bristol, Dublin, &c. The town consists chiefly of a long but narrow street extending along the shore. It contains some fine public buildings, among which may be mentioned the Public Rooms, Polytechnic, town-hall, jail, and market-house. It has also a reading room, mechanics' institute, public baths, savings-bank, and dispensary. Market-days Tuesday and Saturday.

FALSTER, one of the Danish islands in the Baltic, lying E. of the island of Laland, from which it is separated by a narrow strait. It is of an irregularly triangular form, about 27 miles in length from N. to S., but of very variable breadth, the greatest not exceeding 18 miles. The surface is elevated but almost entirely flat. It is richly wooded, fertile, and well cultivated. The chief productions are corn, flax, hemp, hops, potatoes, and fruits. Corn, apples, and other products are exported in considerable quantities. Cattle, hogs, poultry, and bees, are abundant. This island is divided into two districts, north and south Falster. The chief town, Nykiöbing, is on the western side of the island, and in 1850 contained 2123 inhabitants. Pop. of entire island (1850) 23,249.

FALUN, or FAHLUN, a town of Sweden, capital of a cognominal *laen*, and situated near the W. shore of lake Runn, 73 miles W. of Gefle. The town is built chiefly of timber, and the inhabitants, amounting to about 4500, are mostly engaged in mining and smelting. West of the town are the celebrated Falun copper mines, which are the oldest and most celebrated in Europe. They have an historical existence of upwards of 600 years, and it is certain that they are much older—probably by many centuries. In the town are museums of mineralogy and geology, a school of practical mining, a model room, and a large scientific library. The fumes arising from the copper-smelting works destroy vegetation in the vicinity of the town, but do not seem to be injurious to human life; on the contrary, the freedom of the inhabitants from cholera and other serious epidemics which have visited the country has been ascribed to this cause. The laen of Falun has an area of 12,113 square miles, and in 1850 contained 151,497 inhabitants.

FAMA, the goddess of report or rumour, is represented by the ancient poets as the youngest daughter of the Earth, and possessed of wings, with as many ears, eyes, and tongues, as feathers. She is said to have a palace in the air, and to fly through the world by day and by night, hearing and observing all that passes among men. She is mentioned by Hesiod, and particularly described by Virgil and Ovid. She is also described by Chaucer in his *House of Fame;* and by Pope in his *Temple of Fame*, in the following lines:—

So from a spark that kindled first by chance,
With gathering force the quick'ning flames advance:
Till to the clouds their curling heads aspire,
And towers and temples sink in floods of fire.
When thus ripe lies are to perfection sprung,
Full grown, and fit to grace a mortal tongue,
Through thousand vents, impatient, forth they flow,
And rush in millions on the world below.
Fame sits aloft, and points them out their course,
Their date determines, and prescribes their force:
Some to remain, and some to perish soon;
Or wane and wax alternate like the moon.
Around, a thousand winged wonders fly,
Born by the trumpet's blast, and scattered through the sky.

Temple of Fame.

FAMA CLAMOSA, in the judicial procedure of the church of Scotland, a ground of action before a presbytery against one of its members, independently of any regular complaint by a particular accuser.

Any person who is of good character may prefer to the presbytery a complaint against one of its members; but the presbytery is bound not to proceed to the citation of the person accused until the accuser under his hand shall give in the complaint, with some account of its probability, and undertake to make out the libel, under the pain of being considered as a slanderer. But when such an accusation is brought before them, the members are obliged to examine or try the case. Besides this, however, the presbytery considers itself obliged to proceed against any of its members, if the *famá clamosa* of the scandal is such that the person implicated cannot be vindicated unless they begin the process. This they can do without any particular accuser, after they have inquired respecting the origin, occasion, and authors of this report. It is a maxim in the Kirk of Scotland, that religion must suffer if the scandalous or immoral actions of a minister are not corrected; and wherever a minister is reputed guilty of any immorality, although previously the most popular preacher in the kingdom, he is then deserted by his congregation. Therefore the presbytery, for the sake of religion, is obliged to proceed against a minister in case of a *fama clamosa.* This, however, is generally done with great caution. After they have considered the report raised against him, they then order him to be cited, and draw out a full copy of what is reported, with a list of the names of the witnesses to be produced for proving the allegation. He is then formally summoned to appear before them; and he has notice served upon him, at least ten days before the time of his appearance, to give in his answers to what is termed the *libel.* If at the time appointed the minister appear, the libel is read to him, and his answers are also read. If the libel be found relevant, then the presbytery endeavours to bring him to a confession. If a minister absent himself by leaving the place, and prove contumacious, without making any relevant excuse, a new citation is given him, and intimation is made at his own church when the congregation is met, that he is to be holden as confessing, since he refuses to appear before them; and accordingly he is deposed from his office.

FAMAGOSTA, or Famagusta, a seaport-town on the east coast of the island of Cyprus, occupying a low situation between two promontories, in N. Lat. 35. 7. 40., E. Long. 33. 59. It was formerly strongly fortified, and on the land side was surrounded by a deep ditch and thick walls flanked with towers, but these have now fallen into decay. The palace, cathedral, churches, and other buildings, are mostly in ruins, and the town at present probably does not contain more than 200 inhabitants. The harbour was formerly good, but from the accumulation of sand at its mouth it is now only accessible to small craft. Famagosta occupies the site of the ancient Arsinoe. Under the Venetian rule it was one of the principal cities of the Levant.

FAMILY. In a restricted sense the word is applied to those who form one household, whether connected by ties of relationship or not: in a more extended sense it includes the descendants from a common progenitor. Among the Romans the word familia (from *famulus*, a slave or servant) was applied to the household establishment of servants. It was also applied to a collective body of freemen, or to a particular branch of a Roman *gens.* Thus, the gens Æmilia had such subdivisions as the families of Mamerci, Scauri, Lepidi, &c. Of all the institutions that have been established among men, that of the family is the most primitive and the most humanizing. The Creator seems to have placed it as the corner-stone of the social edifice—as the foundation of every organization, political, civil, or religious. We have in it the most manifest proof that man was created to live in society, to go on perfecting his faculties through the multiplied connections which bind him to his kind, and to purify his soul by the affections of his heart. In the family sanctuary we have a clear evidence, that the pretended *state of nature*, which has been represented as the primitive condition of man, is but a barbarous fancy totally opposed to the benevolent designs of the Author of nature.

From the investigation of statistics we learn, that on an average the number of children in one family where polygamy does not exist is—

Years.	In England and Wales. Number of Families.	Average of Persons in each Family.	Average of Persons in each House.	In Scotland. Number of Families.	Average of Persons in each Family.	Average of Persons in each House.
1801	1,896,723	4·688	5·643	364,079	4·418	5·461
1811	2,142,147	4·745	5·655	402,068	4·491	5·939
1821	2,493,423	4·813	5·747	447,960	4·669	6·125
1831	2,911,874	4·772	5·600	502,301	4·707	6·401
1841	Not returned.	?	5·406	550,428	4·760	5·211
1851	3,712,290	4·827	5·469	600,098	4·814	7·801

Family, is used popularly among naturalists to denote an order, class, or genus of animals, or other natural productions having certain characters in common by which they are distinguished from others.

FAN, a simple and well-known implement employed to produce coolness by agitating the air.

Upwards of 3000 years ago the artist of ancient Egypt painted the fan on the walls of the tombs at Thebes, where the Pharaoh sits surrounded by his fan-bearers. These officers acted as generals or marshals, using their fans as standards in war, and in peace they assisted the Pharaoh in the temple, and waved their variegated fans both to produce a cooling breeze, and to guard the sacred offerings from the contamination of noxious insects.

The fan is mentioned by Euripides, and its Grecian forms were far more beautiful than the Egyptian. The wings of a bird joined laterally and attached to a slender handle formed the simple yet graceful fan of the Priest of Isis, when Isis became a Grecian deity. It was sometimes formed of feathers of different lengths, spread out in the form of a semicircle, but pointed at the top. This fan, the precise type of the state-fan of India and China of the present day, was waved by a female slave.

The fan is mentioned by Terence and Ovid; and was termed indifferently "flabellum" or "muscarium." When the Romans were at meals, it was the duty of certain slaves, when the weather was warm, to cool the room with fans and to drive away the flies.

The modern Greek church places a fan in the hands of its deacons to guard the officiating priest and the elements from desecration.

When the fan was brought to France by Catherine de' Medecis, it was so constructed that it could be folded in the manner of those used in the present day. Fans in the luxurious reigns of Louis XIV. and Louis XV., shone with gilding and gems, and were ornamented with the pictures of Boucher

and Watteau. At that time no toilet was esteemed complete without a fan, the cost of which was frequently as high as from L.12 to L.15 sterling.

In fan-making the Chinese and French are the great rivals, and may be said to monoplise the supply of the whole world. In the lacquered fans the superiority of the natives of China is fully admitted. These are unrivalled both in lowness of price and in originality of design, brilliancy of colouring, and in general correctness of workmanship. In China the manufacture of fans is almost entirely confined to Canton, Soutchou, Hang-tchoo, and Nankin. The fans of ivory and bone, and of feathers, are made exclusively for exportation to Europe or America. Those used by the Chinese are of bamboo, polished or japanned, and covered with paper. They are sold at from 10d. to 14s. 6d. per dozen, according to the quality of the frame and the design of the leaf.

In France fan-making has arrived at a high degree of perfection, and presents a remarkable instance of the subdivision of labour: not less than about twenty different operations, performed by as many pairs of hands, are necessary to the production of a fan which sells for less than one halfpenny. The number of fan-makers, or *éventaillistes*, in Paris in 1827 was 15, who employed 1010 workmen (344 men, 500 women, and 166 children), and sold about L.40,420 worth of fans. In 1847, there were 122 fanmakers, comprising chamber-masters as mounters, feuillistes, painters, and colourers. The value of the fans made was L.110,000. These masters employed 575 workpeople (262 men, 264 women, 29 youths, and 20 girls). The workmen on the average can earn 3s. and the women 1s. 8d. per day. Some small fans are sold at a price as low as 5d. per dozen.—(*Reports of the Juries on the Works of Industry at the Exhibition*, 1851.)

FANATICISM (from *fanum*, a temple). Originally, the fanatic was he who performed the duties of a temple, the religious personage, the priest who in the temple was the organ of the god. Whatever may be its etymology, the word *fanaticism* has long been used in a much more limited and discreditable sense. It signifies in common language a religious exaltation which perverts reason and leads to actions that are reprehensible, but which the fanatic believes he ought to do to please God. This is religious fanaticism. In a wider sense this name is given by analogy to all excessive prepossession with any order of ideas, whatever that may be; thus there is a fanaticism for liberty, a fanaticism for patriotism, love, &c. No country has given more lamentable proofs of the pernicious nature of both political and philosophical fanaticism than France, as in the age of philosophical scepticism which preceded the revolution, and in the phrenzy for liberty which produced the fearful excesses and inhumanity of the Terrorists. This fanatical furor produced equally disastrous results under the Reaction or Abolitionist party in Naples and in Spain. Among the republican fanatics of France there were no doubt men of true nobility of soul who were led to the commission of crime by blindly following the hypocritical zeal of their leaders; others, under the cloak of zeal for the public good, were actuated by criminal desires and propensities which have nothing in common with fanaticism. Sir James Mackintosh says: "Fanaticism is the most incurable of all mental diseases, because in all its forms—religious, philosophical, or political—it is distinguished by a sort of mad contempt for *experience*, which alone can correct the errors of practical judgment."

Fanaticism is a real moral malady, a kind of madness, with which imagination has much to do. It finds at first some difficulty in supplanting reason; but if it succeed it becomes then the sole rule of conduct, and generally induces a state of dejection and melancholy. It is never universal in the individual, but rather belongs to that class of mental maladies which is called monomania.

The most deplorable characteristic of this mental disorder is, that it is really contagious, as are all those which depend on the imagination. When once it has established itself in a country, it often assumes the character and authority of a principle, so that many may be for a length of time victims to it without being excited by the same feelings as those in whom it originated. It is thus that human sacrifices most probably commenced and were continued, and that the supposed superior sanctity of the first anchorites spread and multiplied the various orders of monks and friars.

The following is an instance of fanaticism in its most frightful character:—Kiesewetter in his *Pathologie de l'Âme Humaine* relates that a shepherd who dwelt in a village in Prussia often conversed with the schoolmaster of the place on religious subjects. The schoolmaster affirmed that faith and piety were then not nearly so great as in ancient times, especially in the time of the patriarchs, and instanced the faith and obedience of Abraham when commanded to offer up his son Isaac. The shepherd, who had three sons whom he dearly loved, conceived that it would be the most incontestable evidence of his faith and piety were he to sacrifice them to God; and when the tears and prayers of the children for a time stayed his hand and revived humanity in his heart, he reproached himself for listening to the suggestions of the evil spirit, which had prevented him from consummating his good work; but after a short struggle with himself, fanaticism triumphed, and the children fell under the hatchet of their wretched father. This instance, however, may more properly come under the class of monomania. A more criminal species of fanatical acts are those of individuals who have attempted to destroy rulers and others whom they have conceived to be enemies to religion or to political liberty; as, for instance, Jacques Clément, who killed Henri III. of France (1589), and Ravaillac, the assassin of his successor, Henri IV. (1610), and the murderers of Archbishop Sharpe in 1679.

George Fox, Emanuel Swedenborg, and Madame Guyon, are examples of a mystical state of this phrenzy. The fanaticism displayed by the Independents in Cromwell's army and the Scottish Covenanters in the time of Charles II., is of a more noble character, from its being combined with piety and a love of liberty, which nerved its subjects for deeds of valour and endurance. There are instances of this disorder which are only distinguished by ridiculous folly and delusion, such as that of Johanna Southcote, and that of Mrs Buchan, who, in the neighbourhood of Dumfries, in 1786, persuaded her followers that they should never die, but soon be received up into heaven. One morning she led out her people to a hill to take their flight upwards. There they waited till they were tired, but still found themselves fixed to earth; but she assured them that it was their want of faith that prevented their ascension. She then persuaded them that it would be necessary to fast forty days and forty nights, and then they should be taken up. They tried the experiment till some were near dying of starvation, but the trial was too severe, and they dropt off one by one.

When fanaticism manifests itself in atrocities such as murder and assassination, it is more startling; but it is infinitely less disastrous than in the milder type when those who believe that an adherence to certain theological dogmas or actual observances are so essential to the salvation of the soul, that they consider it their duty not only to observe them themselves, but to compel others to take the same track to heaven, although it should be necessary even to resort to pains and penalties to force them.

It is this that has desolated the finest portions of the earth; and it is much to be regretted that the cruelty and oppression of fanaticism has not been confined to the be-

lievers in the Koran or the Shasters, but that in a greater or less degree it has afflicted all the countries calling themselves Christian.

The best means of counteracting the tendency to fanaticism is a vigorous and rational education and a philosophical training. If ignorance is the mother of devotion, it would be unreasonable to expect that such devotion should be enlightened, pure, spiritual, and beneficent. The mind when left uninstructed cannot comprehend the true, and clings more closely to the false.

FANCY. See APPARITIONS, and METAPHYSICS.

FANIONS, small flags carried along with the baggage of an army.

FANNERS, in *Agriculture*, are implements for winnowing corn, or for separating the chaff, husks, and dust, from grain seeds. For descriptions of winnowing machines, see AGRICULTURE, vol. ii., p. 283; and PNEUMATICS.

Among the ancients corn was separated from the chaff by a kind of shovel or broad basket, with which it was thrown in the direction of the wind; and sometimes it was cleaned by means of a sieve, as among the Jews and Greeks. In Virgil (*Georg.* i.) the simple implement used for winnowing is styled *mystica vannus Iacchi*. The *vannus* was borne in the processions celebrated in honour of Bacchus and Ceres, whose rites had a continual reference to rural occupations. It was also used at initiations into the mysteries, as an emblem of that purity of life which was essential; or in other words, to denote the separation of the virtuous from the vicious and profane.

FANO, a city of the Papal States, in the legation of Urbino-e-Pesaro, occupying the site of the ancient *Fanum Fortunæ*, so named from the temple of Fortune there. It afterwards took the name of *Colonia Julia Fanestris* from a colony of veterans who were established here by Augustus; and a triumphal arch of white marble was erected in honour of that emperor, which still forms one of the gates of the city. Fano is situated in a rich and fertile plain on the shores of the Adriatic, at the mouth of the Metauro, 7 miles S.E. of Pesaro. Pop. 10,000. It is inclosed by old walls, with a lofty bastioned front towards the sea, and is richer in churches and paintings than any other town on the east coast of Central Italy. Its cathedral and many of its churches are fine buildings, richly adorned with marbles and frescoes, and containing several masterpieces of the great Italian painters. Fano has a college of Jesuits, a public library, and a modern theatre said to be one of the finest in Italy. Its harbour is so choked up with sand as to be accessible only to vessels of the smallest size, which trade in corn. The town has some manufactures in silk.

FANSHAWE, SIR RICHARD, a distinguished cavalier and accomplished man of letters, was the son of Sir Henry Fanshawe of Ware Park, Hertfordshire. He was born in June 1608, studied at Jesus College, Cambridge, travelled for some time in France and Spain, acquiring the languages and investigating the institutions and manners of those countries; and on his return he entered on that course of diplomatic and public service in which he so eminently excelled. His sympathies and exertions were all on the side of the royalists. Charles I. created him a baronet; and in the service of Charles II. he was taken prisoner at the battle of Worcester. This led to his imprisonment; but through the intercession of Cromwell (who could be a generous as well as formidable enemy) he was liberated. The Restoration brought brilliant hopes to the cavaliers, and Fanshawe was promised the appointment of one of the Secretaries of State. He was however, like many others, doomed to disappointment. Through the influence of Monk the office was given to Sir William Morrice, whom Lady Fanshawe, in her interesting *Memoirs*, terms "a poor country gentleman of about L.200 a-year; a fierce Presbyterian, and one who never saw the king's face." Sir Richard was afterwards employed as ambassador at the courts of Spain and Portugal, and he negotiated the treaty of marriage between Charles II. and the Infanta, Donna Catharina, daughter of John VI. He had just completed an important treaty with Spain, when he was seized with fever at Madrid, and died there on the 4th of June 1665. The widow of Sir Richard (daughter of Sir John Harrison) honoured his memory with a *Memoir*, which forms one of the most interesting, noble, and affecting, of our domestic histories. Though so constantly engaged in posts of honour and peril, Sir Richard Fanshawe found leisure for several translations. The earliest of these was an English version of the *Pastor Fido* of Guarini, published in 1646. This translation has been eulogised by Denham, who applies to it a couplet which seems to draw the line with great felicity between a bad and a good translation:—

> "They but preserve the ashes, thou the flame;
> True to his sense, but truer to his fame."

Fanshawe also translated Fletcher's *Faithful Shepherdess* into Latin verse, the *Lusiad* of Camoens, and some of the Odes of Horace. He was also the author of "A Discourse of the Civil Wars of Rome."

FANTASIA, in *Music*, an Italian term which means either a composition improvised upon the organ, or pianoforte, or violin, &c., according to the free fancy of the performer, and not elaborated according to any strict rules or forms of construction, while still subject to the fundamental laws of melody, modulation, and harmony;—or, a written composition in which the musician indulges his fancy unrestrained by conventional forms of developed themes and movements, but yet bestows more careful attention upon details than is required in the improvised fantasia. One of the finest specimens of a written fantasia is Mozart's in C minor, No. 24 of the list of his works published in 1805 by J. André of Offenbach. The "*Fancies*" of Bird, Bull, and other old English musicians of the sixteenth century, were dry and difficult compositions for a keyed-instrument, worked out upon popular airs. (G. F. G.)

FARCE originally denoted a droll petty show exhibited by charlatans and buffoons in the open street, in order to gather the crowd together. The word is derived, through the medium of the French, from the Latin *farcire, to stuff*, and literally signifies *forced meat* or *stuffing;* and was applied to such exhibitions in allusion to the variety of jests, jibes, and tricks with which the entertainment was interlarded.

The modern farce is a dramatic piece of a low comic character, usually played as an after-piece. Its sole end being to excite mirth, it admits of greater licence than comedy as to probabilities in constructing and developing the plot, and in short may be said to exclude nothing, however wild or extravagant, that may contribute to the amusement of the audience. Dryden observes—"Farce is that in poetry which grotesque is in a picture: the persons and actions of a farce are all unnatural, and the manners false."

FARCY, a disease of the horse, allied to glanders. See VETERINARY SCIENCE.

FAREHAM, a market-town of England, county of Hants, situated at the N.W. extremity of Portsmouth harbour, 73 miles by road and 84 by the South-Western Railway from London. The town consists chiefly of one wide street; and during the summer months is much resorted to for sea-bathing. It has a handsome assembly-room and other conveniences requisite for such places. The manufactures are chiefly sackings, ropes, and coarse earthenware. Some shipbuilding is also carried on. Fareham has some trade in corn, timber, and coal. Market-day, Monday. Pop. (1851) 3451.

FAREWELL, CAPE, the S. extremity of Greenland, on the E. side of the entrance of Davis' Straits, in N. Lat. 59. 49., W. Long. 43. 54. Also a cape at the N. extremity of the middle island of New Zealand; S. Lat. 40. 31., E. Long. 172. 47.

FARINA, the meal or flour of any species of corn; or of any starchy root, as potato, arrow-root, &c.

FARM, or FEORME, an old Saxon word which originally signified *provisions;* and which afterwards came to be used instead of *rent*, because anciently the principal part of the rent of lands was paid in corn, poultry, &c. Hence the word farm, by a gradual departure from its original sense, came to signify the estate or lands (*firma*) so held; and the person holding lands in this way was called a *firmarius* or farmer.

According to the census returns of 1851, the total number of farms in Great Britain was 283,378; of which 223,271 were in England and Wales, 56,150 in Scotland, and 3957 in the islands in the British seas. Of the total number of farms,

190,573	were under			100 acres.
52,912	from	100	to	200
20,603	...	200	...	300
9,031	...	300	...	400
4,063	...	400	...	500
2,248	...	500	...	600
2,816	...	600	...	1000
1,132	...	1000 and upwards.		

The size of 2558 farms was not stated. The average size of farms is 102 acres; and altogether they occupy about one-half of the territory of Great Britain. For observations on farms, see AGRICULTURE, vol. ii., p. 364, *et seq.*

FARMER, HUGH, the well-known author of the *Essay on Demoniacs*, was an English Dissenting minister. He was born in 1714, in the neighbourhood of Shrewsbury, and after receiving a good elementary education, became finally the pupil of the celebrated Dr Doddridge at Northampton. On completing his studies, he was appointed to a charge at Walthamston in Essex, officiating at the same time as chaplain to a wealthy gentleman in the neighbourhood, in whose house he lived. This residence he afterwards exchanged for the more hospitable dwelling of a less aristocratic parishioner, under whose roof he remained for thirty years, thinking out and composing those valuable treatises which afterwards gained him so much distinction. His first work of importance was published in 1761, under the title of *An Inquiry into the Nature and Design of our Lord's Temptation in the Wilderness;* and was designed to prove that the whole of that memorable transaction took place only in vision, and was intended to prefigure the labours and offices of our Lord's future ministry. The originality of the idea, and the great learning with which it was maintained, secured for it a wide and speedy circulation. In 1765 a second edition of it appeared considerably enlarged, in which the objections started against the first edition were answered; and the several subsequent editions were all calculated to strengthen the author's position. In 1771 appeared his "Dissertation on Miracles, designed to show that they are Arguments of a Divine Interposition, and absolute proofs of the Mission and Doctrine of a Prophet." This is the author's most valuable contribution to theological science. The clamour raised against the author, of having borrowed from a treatise on the same subject by Lemoine, was silenced by himself in his *Examination* of the essay of that divine. Farmer's next publication, and the one by which he is best known, though it can hardly claim to be his ablest work, was his *Essay on the Demoniacs of the New Testament*, which may be regarded as a sort of sequel to his treatise on Miracles. The propositions maintained in this volume were attacked with considerable ability but very moderate success by Dr Worthington, a learned clergyman of the English Church, and afterwards by Mr Fell, a Dissenter. Farmer's last work of importance was published in 1783, under the title of "The General Prevalence of the Worship of Human Spirits in the Ancient Heathen Nations, asserted and proved." In 1761, Farmer removed to London, where he continued to officiate to the congregation of Salter's Hall till his death in 1787.

FARMER, *Richard*, D.D., author of the *Essay on the Learning of Shakspeare*, was born at Leicester in 1735. He was educated first at the free grammar-school of his native town, and afterwards at Emmanuel College, Cambridge, of which in 1760 he became classical tutor and in 1775 master. In that latter year also he was appointed vice-chancellor, and three years afterwards chief librarian of the university. In 1780 he was appointed to a prebendal stall in Lichfield, and shortly afterwards prebendary of Canterbury; but after holding this office for a few years, he exchanged it in 1788 for that of a canon residentiary of St Paul's. As none of these offices required constant residence, Dr Farmer spent most of his time at Cambridge, owing among other things it is said to a disappointment in early love which disinclined him to the active business of the world; and there, after a long and painful illness, he died in 1797. A monument erected in his honour bears an inscription by Dr Parr, who describes him as *Vir facetus, et dulcis festique sermonis, Græce et Latine doctus, in explicanda veterum Anglorum poesi subtilis et elegans.* The latter portion of this epitaph has reference to Dr Farmer's only work, his *Essay on the Learning of Shakspeare*, in which the critic proves that the great poet's knowledge of the ancient classics was derived not from the originals, but from translations of which he copied even the blunders. In proving this point, Dr Farmer incidentally illustrates so well the text of Shakspeare, that no other English criticisms on the great dramatist, save the widely dissimilar *Lectures* of Coleridge, and occasional digressive comments interspersed throughout the works of Thomas Carlyle, Mrs Jameson, Mrs Clarke, and other authors of our own day, can compare with his in value.

In politics Dr Farmer was a confirmed Tory; and though an obstinate enemy to change of most kinds, he effected great improvements in the sanitary condition of Cambridge. He greatly enjoyed social recreation, and is said to have had more of the spirit of a boon-companion than of a clergyman. He was twice offered a bishopric by Mr Pitt, and on both occasions he declined the honour which would have debarred him from visiting the theatre, which, it seems, he regularly attended when any work of his favourite author was announced.

FARNABIE, or FARNABY, THOMAS, a grammarian and critical scholar, was born in London in 1575. In his sixteenth year he entered Merton College, which, however, as he was of a restless disposition, he left somewhat abruptly. Passing over into Spain, he embraced the Catholic faith, and entered a college of the Jesuits in that country. The severity of the discipline, however, displeased him, and in 1595 he left the college, to join the last expedition of Drake and Hawkins. He is said to have served afterwards as a soldier in the Low Countries; but he at length returned to England in great poverty, and to meet his immediate necessities opened a school in Cornwall, where, however, he met with no immediate success; and removed to Mattock in Somersetshire, where he began to prosper beyond his utmost hopes. He staid here long enough to establish a considerable reputation, on the strength of which he removed to London and organized a school there, which at one period was attended by upwards of 300 pupils, chiefly the sons of noblemen and gentlemen, and, according to Antony à Wood, turned out a greater number of churchmen and statesmen than any school taught by one man in England. He now received the degree of M.A. from Cambridge, and shortly afterwards the same honour from Oxford. With the money which his success enabled him to realize, he

bought estates in Kent and Surrey, and would in all likelihood have ended his days happily, had he not taken part in the civil wars as a partizan of the king. By the parliament he was taken prisoner and consigned to captivity, first in Newgate and afterwards in Ely House. He died in 1647. His works consist chiefly of annotated editions of *Juvenal* and *Persius*, *Seneca* and *Virgil*. His edition of *Terence*, left unfinished, was completed and published after his death by Dr Merie Casaubon. His other works, such as his *Systema Grammaticum*, are chiefly philological, and have been long superseded.

FARNESE PALACE. See ARCHITECTURE, vol. iii., p. 452.

FARNHAM, a market-town of England, county of Surrey, near the left bank of the Wey, 10 miles W.S.W. of Guildford, and 38 miles from London. Pop. (1851) 3515. The town is built on the S. slope of a hill rising about 700 feet above the level of the sea, and consists principally of two main streets, with a market-place at their intersection. It is well supplied with water from springs in the neighbouring hills, conveyed by pipes to a large reservoir in the town. The parish church is a spacious edifice in the later Gothic style, and was formerly a chapel of ease to Waverley Abbey (founded in 1128), of which some remains still exist in the vicinity. Farnham was early a place of importance, and sent two members to parliament from 4th Edward II. to 38th Henry VI. Farnham Castle on a hill N. of the town, and now the seat of the Bishop of Winchester, was first built by Henry de Blois, Bishop of Winchester, and Brother of King Stephen; but it was razed by Henry III. It was rebuilt and garrisoned for Charles I. by Denham, from whom it was taken in 1642 by Sir W. Waller; and having been dismantled, was restored by Dr Morley, Bishop of Winchester. Farnham was formerly noted for its cloth manufacture, which is now quite extinct. It is chiefly celebrated for hops of a very superior quality, extensively cultivated in the vicinity. Market-day, Thursday. Cobbet was born in the parish of Farnham in 1762, and his remains are interred near the main entrance of the church.

FARNOVIANS, an heretical offshoot from the Socinians, which under the conduct of Stanislaus Farnowski (in Lat. *Farnovius* or *Farnesius*) separated from the other Unitarians in 1568, and attracted within its pale many men eminent for piety, learning, and ability. This schism took place on account of an opinion maintained by Farnovius, that before the foundation of the world Christ was either begotten or produced out of nothing by the supreme God. Farnovius also forbade his followers to pray to the Holy Ghost. These are the only points of the peculiar doctrines of this sect of which we have any knowledge. The Socinians used every effort to draw it back within their pale, and succeeded so well, that on the death of Farnovius in 1615 the sect became utterly extinct.

FARO, a city and seaport of Portugal, province of Algarve, situated on the Valfermosa, near its mouth, 20 miles W. by S. of Tavira. It is surrounded by walls, and contains a cathedral, military hospital, custom-house, arsenal, and several convents and charitable establishments. The harbour is small, but it has a good roadstead. The exports are figs, raisins, almonds, dates, oranges, lemons, wines, cork, sumach, baskets, and anchovies. Pop. about 8000, many of whom are fishermen.

FARO, *Cape*, the ancient *Pelorus*, the N.E. point of the island of Sicily, and one of the three promontories which give a triangular figure to that island. It is situated at the narrowest part of the Strait of Messina, which is thence sometimes called the Faro Channel. The light-house (*faro*) on Faro Cape is in N. Lat. 38. 15. 50., E. Long. 19. 16.

FARO, a game played with cards; one of the most common and simple of all games of hazard.

FAROE, or FEROE (Danish *Färöerne*), a group of islands belonging to Denmark, in the North Sea, between Iceland and the Shetland islands, about 200 miles N.W. of the latter: between N. Lat. 61. 20. and 62. 25., and between W. Long. 6. 16. and 7. 40. The group consists of seventeen inhabited and several uninhabited islands, the former having an area of 490 square miles, and (in 1850) 8150 inhabitants. The principal islands with their populations in 1845 were Strömö 2162, Osterö 1909, Süderö 1156, Vaagö 649, Sandö 528, and Bordö 304. They consist throughout of rocks and hills, rising to a considerable height, and separated from each other by narrow valleys, or rather ravines. Although, however, these hills rise abruptly, there are often on their summits, or at different stages of their ascent, plains of considerable magnitude. They everywhere present to the sea perpendicular cliffs, broken into a thousand fantastic forms, presenting to those who sail along the coast, at every turn, the most picturesque and varied scenery. The highest peak is that of Skellingfell, in the island of Strömö, which rises to about 3000 feet above the sea. The rocks consist generally of trap, and exhibit little variety of composition, though they present some striking geological phenomena. The zeolites and chalcedonies here collected have long supplied the best specimens of these minerals to the cabinets of Europe. Coal is found in Süderö and some of the other islands, and turf is abundant.

The climate is moist and foggy, and violent storms are frequent at all seasons. July and August are the only summer months, but the winters are not very severe. It seldom freezes for more than one month, and the harbours are rarely ice-bound. The only grain crop is barley; and on account of the uncertainty of the weather, it is frequently reaped in a half ripe condition. Agriculture is in a very backward state, the infield, or cultivated land, being calculated to be to the outfield, or uncultivated, in the proportion of one to sixty. The plough is seldom used, being in fact ill suited to the rugged and uneven surface of the land. The ground is therefore turned up with the spade, care being taken not to destroy the roots of the grass. Horses and cows are few in number, and the latter give very little milk, in consequence probably of the very coarse hay upon which they are fed. Sheep are numerous, and form the chief riches of the islanders; some individuals having flocks of from three to five hundred. The sheep are never housed either in summer or winter, and in severe seasons they suffer considerably. The wool is generally coarse, and is torn off the animals in so rough a manner as often to lacerate the skin. The catching of the numerous birds which build their nests upon the face of the cliffs, forms a great source of subsistence to the inhabitants. The persons employed in this hazardous trade display great ingenuity and the most adventurous spirit. Sometimes the fowler is let down from the top of the cliff by a rope fastened to his waist; at other times, where there is any footing at all, he climbs the steepest rocks, or, where that is impossible, he is pushed upwards by poles made for the purpose. The puffin (*Alca arctica*) is the most common of these birds, and the eider duck is here often shot for food. The fisheries are important and valuable.

The monopoly of the trade of the Faroe Islands was for some time in the hands of a mercantile house at Copenhagen; but it has now been assumed by government, and neither Dane nor foreigner is allowed to interfere. The trade is carried on between Copenhagen and Thorshavn. The chief exports are hosiery, tallow, dried and salt fish, train-oil, feathers, skins, and butter.

Thorshavn, the capital of these islands, is situated on the S.E. side of the island of Strömö, upon a narrow tongue of land, having creeks on each side, where ships may be safely moored. Pop. about 1500. The houses are built of wood, and roofed with birch bark covered with turf, the greenness

Farquhar.

of which makes it impossible at a very short distance to distinguish the place from the surrounding fields. The character of the people is generally marked by great simplicity of manners, kindness, and hospitality. They are well fed and clothed, and seem to be kindly treated by the Danish government. The average duration of life, as stated by Dr Panum, is 44⅝ years; while in Denmark it is only 36. The language of the people is a remnant of the old Norse, but that of the courts, churches, and schools, is the modern Danish. See *Færoæ and Færoæ Reserata*, by Lucas Jacobson Debes, translated from the Danish into English, 1675; *Description of the Faroe Islands*, by the Rev. G. Landt, London, 1810: an account of their geology and mineralogy in the Trans. of the Royal Soc., Edin., vol. vii., by Sir G. S. Mackenzie, Bart., and Thomas Allan Esq.; Den Danske Stats Statistik., vol. iv., 1853: J. Nichol's *Account of Iceland, Greenland, and the Feroe Isles:* Dr Panum's *Official Report on the Diseases of Feroe*, 1849, of which an abstract appeared in vol. vii. of the *Medico-chirurgical Review*. The scenery of these islands is well illustrated in a work entitled *Cruises of the Yacht Maria*. Lond. 1855.

FARQUHAR, George, a comic dramatist of the school of Wycherley and Congreve, was a native of Ireland, the son of a clergyman in Londonderry, and born in the year 1678. He early rose into distinction, and his brief successful career was closed before he was thirty. In his sixteenth year he was entered of Trinity College, Dublin; in his seventeenth he was an actor on the Dublin stage; in his eighteenth he had quitted the theatrical profession and was in London; and in his twentieth year his first play, *Love and a Bottle*, was brought out with applause at Drury Lane. His connection with the stage as an actor was suddenly terminated in consequence of an accident. While performing in Dryden's *Indian Emperor*, he had omitted to exchange his sword for a foil, and in a fencing scene seriously wounded a brother actor. The latter recovered, but the young and sensitive author of the misfortune resolved to leave the stage for ever. In less than nine years Farquhar had produced seven popular comedies,—his *Love and a Bottle; The Constant Couple, or a Trip to the Jubilee; Sir Harry Wildair*, a sequel to *The Constant Couple; The Inconstant, or the Way to Win Him; The Twin Rivals; The Recruiting Officer;* and *The Beaux Stratagem*. He also published (1702) a volume of *Miscellanies*, consisting of short poems, letters, and essays, with a *Discourse upon Comedy*, in which he defends the English disregard of the dramatic unities. The poems and letters are in that style of affected licentious gallantry and smartness which was then thought witty and fashionable. They have no redeeming feature. The letters are said to have been addressed to Mrs Oldfield, the celebrated actress whom Pope, in his imitation of the second satire of the first book of Horace, happily characterizes, as—

> Engaging Oldfield! who, with grace and ease,
> Could join the arts to ruin and to please.

The stage at this time was but slightly purified from the grossness and immorality that had overflowed the theatres like a spring-tide flood at the period of the Restoration; and neither the lives nor the writings of dramatic authors or performers will bear a close scrutiny. Farquhar is less designedly and elaborately immoral than Wycherley or Congreve, yet there are few of his scenes that do not require pruning or excision. Love intrigues then formed the chief business of the comic drama; and in the management of them, the homely domestic virtues that are the happiness and cement of society were totally disregarded, or made the subject of ridicule. Seriousness was synonymous with hypocrisy, and the gaieties of a town life were held up as the end and aim of existence. It is true that the world of comedy was an artificial world,—never, perhaps, regarded as real, or as a pattern of morals or manners; but the effect of such representations was to lower and corrupt the national taste and principles, while the fact that no pursuit was so profitable to an author as writing for the stage was also injurious to our imaginative literature. Considering the standard of taste and morals at the time Farquhar wrote, and for half a century afterwards, of which the *Suffolk Correspondence*, *Lord Hervey's Memoirs of the Court*, and other works, afford ample evidence, we need not wonder at the success of his plays. His plots are skilfully conducted and evolved, his situations well chosen, and his dialogue full of life and spirit. Goldsmith preferred Farquhar to Congreve, while Pope considered him a mere farce writer. The truth lies between the two. Congreve was the more polished and consummate artist,—his wit is brilliant and cutting as a diamond. Farquhar is easy, natural, and lively,—overflowing as it were with animal spirits and robust health. In the delineation of character he is eminently happy. His Sergeant Kite, Scrub, Archer, and Boniface, are distinct, pronounced characters, that still charm from their freshness and originality; while the incidents with which they are mixed up—the unexpected encounters, artifices, and disguises—are irresistibly comic and effective on the stage. The personal history of Farquhar is that of a careless dissipated "man upon town." He received from the Earl of Orrery a commission as lieutenant in his lordship's regiment, and is said to have given proof of conduct and courage as a soldier. In what service he was employed is not stated, but he could not have had any arduous military duty. The stage, not the tented field, was his scene of action. He appears, however, to have been in Holland in 1700, as one of his letters is dated from the Brill and another from Leyden. He took pains to conciliate patrons by flattering dedications prefixed to his plays, and he attempted to better his fortunes by marriage. Some lady, we are told, conceived a violent passion for him, and circulated a report that she had a large fortune. Farquhar fell into the snare, he married the lady, and found out too late his mistake; but he had the magnanimity, it is said, to pardon a deception that must have appeared a compliment to his genius. There was, however, something to forgive on his own part for snatching so readily at the gilded bait, contrary to all the rules of love and the drama. He was always in difficulties. He was forced to sell his commission; and after finishing his last and best play, *The Beaux Stratagem*, in six weeks, while death was impending over him, he left his two children to the care of Wilks the actor. "Dear Bob," he said in a farewell epistle, "I have not anything to leave thee to perpetuate my memory, but two helpless girls; look upon them sometimes, and think of him that was to the last moment of his life thine, George Farquhar." Wilks did not forget the melancholy request, but he probably had little to give. One daughter became a servant, and the other married a "low tradesman," while the mother lived and died in the utmost poverty. Thus the life of Farquhar, spent as a jest, became in the end a sad and instructive reality. He died in London, and the parish register of St Martin's-in-the-Fields obscurely records his burial in this fashion,—"23 *May*, 1707. *George Falkwere*." (R. C—S.)

Farrier ‖ Farringdon, Great.

FARRIER (from the Lat. *ferrum*, iron; whence in some old authors written *ferrier* and *ferrer*); one who shoes horses, or one whose business it is to cure horses and other animals when diseased or lame. The medical and surgical treatment of the domestic animals constitutes what is termed the veterinary art.

FARRIERY. See Veterinary Science.

FARRINGDON, Great, a market-town of Berkshire, situated at the foot of Farringdon Hill, about 2 miles from the Thames, 30 W.N.W. of Reading, and 68 from London. Pop. (1851) 2456. The town is neat, clean, lighted with gas, and well supplied with water from the spring of Port-

well. The streets diverge from the centre of the town, where the town-hall is situated. The parish church is an interesting Gothic structure of different periods, the E. end being of great antiquity. Market-day, Tuesday. Farringdon carries on an extensive trade in corn and bacon.

FARS, or Farsistan, a province in the S.W. of Persia, bounded on the N. by Irak and Khorassan, E. by Kirman, S.E. by Laristan, S.W. and W. by the Persian Gulf, and N.W. by Khuzistan. It lies between Lat. 27. 40. and 31. 52. N., and between Long. 49. 30. and 55. 20. E. This province is divided into the Germaseer and Sirhud, or the warm and the cold climates. It is in general sandy and barren, though with some considerable exceptions. The Tabris, formed by the junction (within a few miles of the town of Zeitoon) of two streams which take their rise in the mountains of Fars, is the most considerable river of the province. It divides Fars from Khuzistan, and falls into the sea eight miles below the town of Endian. The warm region of this district extends from the sea to the latitude of Kazeroon, and runs parallel with the gulf from the banks of the Tabris to the confines of Laristan. It is chiefly a sandy plain at the foot of the mountains, the cultivation of which depends on the periodical rains; and when these prove abundant, the country yields abundance of dry grain; but when the rains fail, which too frequently happens, a famine generally ensues. The sandy plain, or the Dushtistan as it is called, is divided into two districts, which are separated by the projecting mountain of Bung. These two districts are thinly peopled and badly cultivated; and the few mud villages which are scattered over the plain bespeak but too clearly the poverty and wretchedness of their possessors. The cold region comprehends most of the mountainous part of Fars, extending from the latitude of Kazeroon to that of the town of Yezdekhast, situated on the bed of what appears to have been formerly a river, and which separates this province from Irak. The mountains are here intersected by plains, which seldom exceed eight or ten miles in breadth, whilst in length they vary from fifteen to a hundred. They are in general fertile, affording abundance of pasturage; nor are they so deficient in water as they have sometimes been represented. A few of them, such as those of Shirauz, Kazeroon, and Merdesht, are tolerably well cultivated; but they are for the most part, particularly to the northward and westward, destitute of inhabitants. It is mentioned by Kinneir, in his Geographical Memoir of the Persian Empire, that in 1809 he travelled in this country "through the most delightful valleys, covered with wood and verdure," but all was solitary, nor was the face of a human being anywhere to be seen. The face of the country in the eastern parts of Fars is somewhat different, being open, the plains of greater extent, and of a sandy soil, where water is not so plentiful. The great range of mountains seen from the coast is a mere elongation of the chain of Mount Tagros, which extends in a continued succession of ridges from the borders of the Persian Gulf to the Caspian Sea and the Caucasus. These hills in Fars are situated at different distances from the sea. At Bushire they are distant 24 miles; but towards Bunder Reig the plain becomes contracted; and a low ridge, known by the name of Kohi-Bung, or the hill of Bung, about seven or eight miles broad, suddenly projects to the south, and touching the sea, separates the district of Leerawee from that of Hiadouat. Beyond this hill, at the plain of Leerawee, the mountains are about 20 miles distant from the sea, at which distance they continue for 18 or 19 miles, when they again approach the south. This branch is known by the name of Zeitoon, on turning the southern point of which they again abruptly retire to the northward; and at the port of Mashoor they are 30 miles from the sea. The principal towns of the province are Shiraz, the capital; Bushire, the chief port in the Persian Gulf; Darabjerb, Bebahan, and some others. Within its confines also are the ruins of the cities of Shakpoor, Persaga, and Persepolis.

FARTASH, or Fartak, a cape on the S. coast of Arabia, province of Hadhramaut; Lat. 15. 36. 40. N., Long. 52. 21. 10. E.

FARTHING, a small English copper coin, amounting to one-fourth of a penny. It was anciently called *fourthing*, as being the fourth of the integer or penny. A farthing of gold, equal in value to the fourth part of a noble or 20d. in silver, is mentioned in statute 9th Henry V., cap. 7.

FARTHINGALE, a petticoat extended by hoops or circles of whalebone; and first worn, it it said, by pregnant women. The fashion was introduced into England in the reign of Queen Elizabeth; and the last remnant of it, namely the single hoop, only disappeared about the year 1820.

FASCES, in *Roman Antiquity*, a symbol of authority introduced by the kings, consisting of a bundle of rods, usually of birch, tied together, and containing an axe, the head of which was allowed to project. Officers named *lictores* were appointed to carry the fasces, and varied in number according to the dignity and importance of the magistrate whom it was their duty to precede. In the regal times of Rome, 12 of these officers, each carrying the fasces, preceded the king whenever he walked abroad. After the expulsion of the Tarquins the consuls were allowed 12 lictors each, but the axes were only borne before one of them at a time. Publicola got a law passed according to which only one of the consuls was allowed the fasces when both these magistrates were in the city at the same time. The other was attended by a single officer, named *accensus*. It was also ordained that the axes should be removed from the fasces, unless when the consul was in the camp. The dictator, however, was preceded by 24 lictors, and even in the city was allowed to retain the axes. The prætors were each allowed two when in the city, but when on military service the number was increased to six. The tribunes of the people, ædiles, and quæstors, were not allowed lictors in the city; but the quæstors might have them in the provinces.

FASCIA, among the ancient Romans, denoted a band, sash, or long piece of cloth, used to wrap about the legs and thighs; to swathe new-born infants; or for any similar purpose. In astronomy the term *fascia* is applied to the belt of a planet; and in architecture to any flat member with a little projection, as the band of an architrave. (See *Glossary* to Architecture.)

FASCINATION, a sort of witchcraft or enchantment supposed to operate either by the eye or the tongue. Among the ancient Greeks and Romans it was a prevalent belief that some persons had the power of injuring others, particularly children, and even cattle, by their looks; and various amulets were employed to avert the imaginary evil. See Evil Eye.

FASCINES (*fascis*, a bundle), in *Fortification*, faggots, or bundles of rods, or small branches of trees, bound together in several places. They are used for various purposes, such as raising batteries, filling ditches, forming parapets, &c.; and vary in dimensions according to the purposes to which they are to be applied. Fascines dipped in pitch are sometimes employed to fire the enemy's lodgements or other works.

FASHION. It was the ordinary remark of the fashionable Doctor Graham (in the days of Horace Walpole), when consulted by a patient—"Sir, your disease is very extraordinary, but it is common enough." This paradoxical definition may be very well applied as interpreting the word "Fashion." The latter is doubtless an extraordinary thing commonly adopted. It will seem still further paradoxical to assert that what is "fashionable" is "vulgar"; but when it is recollected that "vulgar" implies something popularly observed (the word being derived from "volk," "*people*"), the paradox is no longer apparent. The Latin

terms *vulgus* and *vulgaris*, like our own translations of them, are not intended to convey anything complimentary in them. The designation *vulgus* was contemptuously flung at the ancient Germans by their Roman antagonists. The sons of Herman accepted the name, and the German "volk" soon became the fashionable or popular equivalent for "patriots."

In the term "mode" we have something of a similar meaning. It is derived from *mos*, a manner or custom. This word in its plural form, *mores*, signifies "morals," by which is meant manners, which, if not, ought to be, in fashion. As in Latin the difference of number alters the signification, so in French does the change of gender. "Le moral," of a woman, is, for instance, by no means the same thing as "sa morale." In deriving *mode* from "mos," we follow the lexicographer Boiste. We may add, however, that another Latin word, "modus," is not altogether to be set aside as the original of "mode." It implies a due proportion, neither more nor less; a just measure or manner; and to be in the mode, according to this rendering of the original, is not to be extravagant, not to be in excess in anything. He who adopts *this* mode will find himself possessed of the most valuable of fashions—the true "*factio nobilium*;" although Livy had not the same application in his mind when he wrote the words just quoted.

The most ancient fashion with which we are acquainted is one which is just expiring. It commenced in Scythia, and is going out, after a long reign, in New Zealand. We allude to "tatooing." It is, or was, the offspring of some strange conceit on the part of the ladies. These latter were Scythians, who, holding in their power some Thracians of the same sex, amused themselves, says Clearchus, by tracing very ridiculous figures on their bodies, by means of needles. The poor Thracian ladies, when restored to freedom, exercised their ingenuity by concealing the absurd figures etched on their bodies, in a labyrinth of flourishes, circles, and most perplexing patterns. The design was immediately adopted as fashionable wear, and every Thracian lady appeared in public tatooed from the head to the loins. Since that period, the mode has been followed by various nations, and until very recently it was the characteristic of the New Zealand aristocracy. Of late years, however, the young chiefs look with something of contempt on their seniors so distinguished; and very speedily a tatooed skin will be as rare a thing in the isles of the Southern Ocean as perukes and patches, clouded canes and farthingales, in the public promenades of England.

The fashions of the conqueror generally prevail over those of the conquered. Thus young British chieftains, despite the disgust of their sires, threw off their vesture of skins and put on the habits of their Roman victors. A consequence, only partially similar, followed the Norman invasion; the Norman cavaliers took from the Saxons their "smock-frocks," and with a change of material and an addition of ornament introduced the *blouse*. When not engaged in military duties, the same invaders doffed their iron head-pieces, and donned a wide-brimmed and easy covering of felt;—this was nothing more than the modern "wide-awake." The *couvre-chef* of the lounging Norman has been stiffened into the peculiar head-gear of the Society of Friends; but its chief glory consists in its having been in a modified shape and a scarlet hue patronized by the Church of Rome, and fixed upon the brows of her humble cardinals.

Some one has defined "fashion" as being "the tyrant of fops and females." The definer might have added that the artificers in fashion's service are often the victims of fashion's slaves. There is nothing so powerful, so absolute, so imperious, and so transitory, as this same fashion. Napoleon himself was jealous even of this so-called goddess; and he condescended to sneer at her votaries, by saying that nations are sheep-like, and ready to follow the first who sets a strange example. The simile is ricketty, and is not entirely correct. We have never heard of any one who followed the fashion set and advocated by Asclepiades, who tried to bring cheap locomotion into general favour, and who travelled about the world on a cow, living on her milk by the way.

The above is an example set, which has never been followed. We may cite on the other hand a fashion followed, the originating example for which no one has yet discovered. We allude to "smoking." Of course, at this word, the thoughts naturally revert to Sir Walter Raleigh and Virginian tobacco. There were pipes, however, in our old monasteries, and the monks smoked "colt's-foot" to keep the marsh air out of their stomachs. The fashion is probably of Eastern origin. That mention is not made thereof throughout the *Arabian Nights* is no proof to the contrary, for we believe that in that picturesque series the undeniably prevalent Eastern fashion of opium-eating is not even alluded to.

Fashion, in its sense of the way of doing a thing, is not confined to matters of dress alone. It extends itself to far sublimer subjects, rules our manner of life, gives opinions to those who have none of their own, and is sometimes powerful even in *articulo mortis*. As a sample of the last, it is only necessary to name the case of Father Sachot, the priest of St Gervais. In the middle of the seventeenth century he was the fashionable confessor at death-beds. Happy was the moribund who could secure the pleasant presence of the not too exacting Father Sachot. On the other hand, the patients on whom he could not wait, and who were unable to receive absolution at his hands, were miserable, and obstinately refused to die with solemn aid from any other hand. Men "of quality"—as it was, and is, the bad fashion to call a certain class of persons, without reference to the question of good or evil quality—men of quality thought more of Father Sachot than of their heavenly Father.

A similar mistake possessed those who in our great grandsires' days flung away their thousands upon a flower. The Egyptians worshipped onions, for the semi-reasonable cause that they symbolized a god. The tulip-fanciers had little regard, when contemplating their petalled favourites, for either flowers themselves or the god at whose bidding they had risen into beauty. As La Bruyère remarks, they simply worshipped their tulip-bulbs, and would have adored carnations if carnations had been more in fashion.

As in flowers, so have we had a fashion in colours. The "couleur Isabelle" was a dirty buff. It was adopted in honourable memory of the condition of the linen of Isabelle, the *gouvernante* of Flanders, who refused to change any portion of her dress during the long protracted siege of Ostend. The "patches" on the cheeks of the belles of a century and a half ago were assumed in order to give consolation to a princess suffering from a natural eruption. There was more sense in the fashion of patches as adopted by the lightly-clad ladies of the Samoa Island. This "fashion of spots," as it is called, or *sangisengi*, consists in the raising of small blisters with a smouldering wick of native cloth, a material which will not blaze. When the blisters are healed, a natural patch is left, which is lighter than the original skin. This indelible spot is planted on the cheek, not for beauty's sake, but with something of the purpose which supplies our churches with painted windows; namely, in pious memory of deceased relatives, or in grateful acknowledgment of benefits received.

This religious fashion reminds us that the Scriptures contain no notice whatever of the vocation of a tailor. The meek members of the useful craft need not, however, be discouraged. Lydia of Thyatira followed the occupation of

Fashion. making up into garments the purple cloth for which the country named Lydia was famous; and Lydia stands enviably recorded as being among the first who joined Paul in prayer by the river side at Philippi. One would have supposed that the great apostle would have been selected by the fashioners of costume as their patron-saint. This, however, is not the case. The milliners and dressmakers before the Reformation did homage to a visionary "St Veronica," and the tailors in olden times put up their orisons to the united nine St Williams who stand upon the calendar of Rome.

The most pious of men, it may be observed, were not above some regard for fashion, even with reference to very small matters. Thus, in the days of Elizabeth and James no Puritan divine ever went to bed but with his head in a night-cap of black silk tipped with white. Under the same sovereigns, doctors of medicine and privy-councillors sank to sleep in night-caps wrought with gold silk. Similar head-gear was worn by our princes. At the marriage of Frederick Prince of Wales, the ill-conditioned son of the worse-conditioned George II., the royal bridegroom was splendid at night in his robe of gold tissue and a night-cap wrought with gold silk. Thus attired, he glided among the crowd of fashionable people who stood in the bed-room to greet the illustrious pair; and with this marriage went out the unseemly fashion of such public greetings.

We have before alluded to the long prevalence of some fashions. We are inclined to think that the excessive growth of the nails, as indications of rank (the wearers of them being necessarily above manual labour), a fashion not confined to China, but followed also in Upper Nubia, where the growth is encouraged by holding the nails over small fires of cedar wood; we are inclined, we say, to think that such fashion, if it does not date from the time of Adam, prevails in the localities named, only because of him. There is, at all events, a Rabbinical tradition which says, that before the fall, Adam and Eve had a transparent covering, a robe of light, of which remnants remain to mankind in the nails of the hands and feet. To encourage the growth of the nail was, probably, in its original sense, only to recover as much as possible of the robe of light which decked the forms of the parents of mankind. Did the old British astronomers wear green robes with any reference to the older legend in the East, that the original colour of the father and mother of men was a sea-green? That colour is said to have been sacred in the East long before the time in which the Prophet of Islam adopted it as the holy hue, which none might thenceforth wear save the members of his own family; and the fashion may have been adopted by the father of the faithful in remembrance of its traditionary connection with the father of us all. The green, for dress, whether as assumed by British astronomer or prophet from Yemen, was in better taste than a mode of our Saxon ladies who, before the Norman invasion, thought they heightened their beauty by dying their hair *blue!* They seldom, however, changed the fashion of their garments according to the variation of the seasons. The summers then, as now, seldom came to maturity, and it was this fact which induced Boerhaave to prescribe the old Saxon custom as a good sanitary fashion. "In England," said Boerhaave, "a man should never lay aside his winter costume until Midsummer-day, and he should put it on again the day after." If this fashion, with some necessary modification, were adopted, one happy consequence would undoubtedly follow; phthisis would not be the fashionable, or rather national malady of England. Madame Cottin, in her *Mathilde*, says that modesty is the most seductive of garments. The assertion is one made in the fashion of the good ladies of the last century, who thought themselves moralists. They all err in their mode of giving a meretricious recommendation to modesty; and the too-joyous Irish bard was not much more sillily employed, when he anathematized flannel and sought to give *éclât* to the ague.

Fast.

Perhaps it was an abhorrence of the latter that brought into fashion the foot-races that in the last century used to be run on Sunday afternoons in Kensington Gardens by the "Maccaronis." There was nothing, for a time, more decidedly in vogue than these profane sports. The mob looked on, applauded and despised the performers. Of all our sporting fashions it was perhaps the one most disgraceful to us. We may add while on this subject, that although cricket as a Sunday sport has gone out of fashion, it is still a game which may be legally played on the day named, provided that all the players be of the same parish. The intention, no doubt, was to prevent "matches" on the Sabbath. The regulation, as showing the fashion of the times, is worth mentioning.

Finally, reverting to "fashion" as simply in connection with dress, its past history reveals to us the counterfeit presentment of our ancestors; its present history, to be found in various contemporary authors, will convey a reflection of ourselves to those who will succeed us. It is a subject which unceasingly occupies the fool, and only passingly concerns the philosopher. Diogenes was not anything the more of a philosopher for living in a tub. He affected to fly the fashions of his day; but it has been truly remarked that while a fop is the slave of fashion, a philosopher surrenders himself to his tailor, whose duty lies in dressing him becomingly. He who entirely despises becomingness of attire, under an affected or an imaginary contempt for fashion, is as weak of head and mistaken in employment as he who sets all duties below the pleasure of watching the fashions and adopting them. These perish with daily perishing time, and as the moralist of Dourdan sensibly remarks:—"La vertu seule, si peu à la mode, va au-delà des temps." (J. D—R—N.)

FAST, properly signifies abstinence from food; and in a theological sense is used to denote voluntary abstinence from food, or particular kinds of food, as a religious mortification or humiliation. Religious fasting has been practised by most nations from the remotest antiquity; and some divines would even refer its origin to the command by which our first parents were forbidden to eat of the tree of knowledge. It is, however, certain that the Jewish church has observed fasts ever since its first institution. Nor were the neighbouring nations, the Egyptians, Phœnicians, and Assyrians, without their fasts. The Egyptians, according to Herodotus, sacrificed a cow to Isis, after having prepared themselves by fasting and prayer; a custom which he likewise ascribes to the women of Cyrene. Porphyry affirms that the Egyptians, before their stated sacrifices, always rested a number of days, sometimes even of weeks; and that during this time the priests and devotees not only abstained from flesh, fish, wine, and oil, but even from bread, and some kinds of pulse. These austerities were communicated by them to the Greeks, who observed their fasts much in the same manner. The Athenians had the Eleusinian and Thesmophorian fasts, the observance of which was very rigorous, especially among the women, who spent one whole day sitting on the ground in a dress of mourning, without taking any nourishment. In the island of Crete the priests of Jupiter were obliged to abstain during their whole lives from fish, flesh, and baked meats. Apuleius relates, that whoever desired to be initiated in the mysteries of Cybele was obliged to prepare himself by fasting ten days; and indeed, with respect to all the pagan deities, this duty was required of those who desired to be initiated into their mysteries, of the priests and priestesses who gave out the oracles, and of those who came to consult them. Amongst the heathens fasting was also practised before some of their military enterprises. Aristotle relates that the Lacedæmonians, having resolved to succour a city of the allies, ordained a fast throughout the whole extent of

their dominions, without excepting even the domestic animals; and this they did for two ends, first, to spare provisions in favour of the besieged, and, secondly, to draw down the blessing of heaven upon their enterprise. The inhabitants of Tarentum, when besieged by the Romans, demanded succours from their neighbours of Rhegium, who immediately commanded a fast throughout their whole territories. Their enterprise having proved successful by throwing a supply of provisions into the town, the Romans were obliged to raise the siege; and the Tarentines, in memory of this deliverance, instituted a fast to be annually observed ever afterwards.

Fasting was practised at Rome both by kings and emperors. Numa Pompilius, Julius Cæsar, Augustus, Vespasian, and others, we are told, observed stated fasts; and Julian the Apostate was so exact in this observance as to outdo the priests themselves, and even the most rigid philosophers. The Pythagoreans kept a continual lent; but with this difference, that they believed the use of fish to be equally unlawful with that of flesh. Besides their constant temperance, they also frequently fasted rigidly for a considerable time. In this respect, however, they were all outdone by their master Pythagoras, who was said to fast for no less than fifty days together! Even Apollonius Tyaneus, one of his most celebrated disciples, could never equal his master in the length of his fasts, though in these he greatly exceeded other Pythagoreans. The Gymnosophists, or Brahmins of the East, are also remarkable for their severe fastings; and the Chinese have likewise their stated fasts, with forms of prayer, for preserving them from barrenness, inundations, earthquakes, and other calamities. The Mohammedans too, who possess so large a part of Asia, are remarkable for the strict observance of fasts; and the exactness of their dervises in this respect is extraordinary. (See Mohammedanism.)

Fasting was often used by the heathens for superstitious purposes; as to procure the interpretation of dreams, &c. The Jews have added several fasts not commanded in the law of Moses, particularly three, in memory of great national calamities. The sole fast required by Moses was on the great day of annual atonement. The abstinence of the ancient Jews commonly lasted twenty-seven or twenty-eight hours at a time, beginning before sunset, and not ending till some hours after sunset the next day. On these days they covered themselves with sackcloth, sprinkled ashes on their heads, and performed other like ceremonies. The ancients, both Jews and pagans, had also their fasts for purifying the body, particularly the priests and such as were employed at the altars; and at great festivals it was usual for them, on the preceding eve, not only to abstain from food but also from sleep.

With regard to this observance among Christians, as fasts are nowhere expressly enjoined by our Saviour, and as his disciples, while he was with them, were notorious for not fasting, some have contended that such observances are not required from his followers. They explain the passage (Matth. ix. 15) where Christ says that the days will come when his disciples shall fast, as merely intimating the approach of a period of mourning, and signifying rather sorrow of mind than corporeal self-denial. The apostles and early Christians, however, are frequently represented as fasting, especially on solemn occasions; as when Paul and Barnabas are sent forth by the apostles to preach to the Gentiles (Acts xiii. 2). Our Saviour too, in reprobating its abuses among the Pharisees, never objects to its legitimate use (Matth. vi. 17). Though fasting cannot in itself be looked upon as a meritorious work, yet there seems to be little doubt that its occasional use is beneficial, as tending to induce a frame of mind that is favourable to meditation and devotion. (See also Abstinence.)

FASTERN'S EVE, in Scotland, the name given in the times of popery to Shrove-Tuesday, or the day immediately preceding Ash-Wednesday. The name is still retained.

FASTI, in *Roman Antiquity*, the kalendar in which were comprised the various days of the year, with their feasts, games, and other ceremonies.

There were two kinds of *fasti*, the greater and less; the former distinguished by the appellation of *fasti magistrales*, and the latter by that of *fasti kalendares*. The *fasti kalendares*, which were properly and primarily called *fasti*, are defined by Festus Pompeius to be books containing a description of the whole year, that is, ephemerides or diaries, in which the several kinds of days—*festi, profesti, fasti, nefasti*—are distinguished. The author of these was Numa, who committed the care and direction of the *fasti* to the *pontifex maximus*, by whose advice the people were guided on these points. This custom continued until the year of Rome 450, when C. Flavius, secretary to the pontifices, exposed in the forum a list of all the days on which it was lawful to work; and this proved so acceptable to the people that they made him curule ædile. The *fasti kalendares* were of two kinds, namely, *urbani* and *rustici*. The *fasti urbani* were those which obtained or were observed in the city. Some are of opinion that they were thus called because they were exposed publicly in different parts of the city; though from the various inscriptions it may be conjectured that private persons had likewise *fasti* in their houses. Ovid undertook to illustrate these *fasti urbani*, and comment on them, in his *Libri Fastorum*, of which only the first six books are extant. In the *fasti rustici*, or country *fasti*, were expressed the several days, feasts, and the like, to be observed by the country people. For as the latter were occupied in tilling the ground, fewer feasts, sacrifices, ceremonies, and holidays were enjoined on them than on the inhabitants of cities; and they had also some peculiar ones not observed at Rome. These rustic *fasti* contained little more than the ceremonies of the kalends, nones, and ides; the fairs, signs of the zodiac, increase and decrease of the days, the tutelary gods of each month, and certain directions for rustic labours to be performed each month. In the great fasti, or *fasti magistrales*, were expressed the several feasts, with everything relating to the gods, religion, and the magistrates; the emperors, their birthdays, offices, days consecrated to them, with feasts and ceremonies established in their honour, or for their prosperity. When flattery had at length swelled the *fasti* with a number of such circumstances, they came to be denominated *magni*, in order to distinguish them from the bare kalendar, or *fasti kalendares*.

Fasti was also a chronicle or register of time, in which the several years were denoted by the respective consuls, with the principal events which happened during their consulates. This register was denominated *fasti consulares*, or the consular *fasti*.

Fasti, or *Dies Fasti*, likewise denoted court days. The word *fasti fastorum* is formed from the verb *fari* to speak, because during those days the courts were opened, causes might be heard, and the prætor was allowed *fari*, to pronounce the three words, *do, dico, addico*. The days in which this was prohibited were called *nefasti*. Hence Ovid says,

> Ille ne fastus erit, per quem tria verba silentur,
> Fastus erit, per quem lege licebit agi.

The *dies fasti* were noted in the kalendar by the letter *F*; but it is to be observed that there were some days *ex parte fasti*, partly *fasti*, partly *nefasti*, in which justice might be distributed at certain times of the day, and not at others. These days were called *intercisi*, and were marked in the kalendar by the letters *F. P. fasto primo*, in which justice might be demanded during the first part of that day.

FASTOLFF, Sir John, a distinguished English officer, born at Yarmouth in Norfolk in 1377. He held many places of trust and importance in Ireland, and afterwards in France. For his bravery at Agincourt, where he was wounded, he

received a grant of land in Normandy. After distinguishing himself at the siege of Orleans he fled ignominiously from the field of Patay before the victorious Joan of Arc. For this inglorious conduct he was temporarily degraded, but afterwards restored to his honours. On returning to England he signalized himself by his encouragement of literature, bestowing large sums on Cambridge, and endowing Magdalen College with special liberality. He died in 1459 at the age of eighty. It is merely a gratuitous supposition to imagine, as some writers have done, that Shakspeare had this officer in his eye in delineating the character of Sir John Falstaff. There was not the most distant resemblance between the moral, physical, or intellectual characteristics of the two men.

FAT, an oily concrete substance, contained in the cells of the adipose or cellular membrane of animal bodies. See ANATOMY, ii. 787, and CHEMISTRY.

FAT also denotes a measure of capacity, but indefinite. Thus a fat of isinglass contains from $3\frac{1}{4}$ cwt. to 4 cwt.; of yarn, from 220 to 221 bundles, &c.

FAT or VAT, a large wooden tub or vessel used in breweries and tanneries; also as a measure for malt, containing eight bushels.

FATA MORGANA (or the castles of the "fairy Morgana"), a remarkable optical illusion depending on *mirage* or unusual atmospherical refraction, which has been described by various philosophical writers and travellers as observed in the Straits of Messina, between the coasts of Sicily and Calabria. The following account of this aërial phenomenon is taken from Minasi's dissertation on the subject, published at Rome in 1773. "When the rising sun shines from that point whence its incident ray forms an angle of about 45° on the sea of Reggio, and the bright surface of the water in the bay is undisturbed either by the wind or the current,—a spectator standing upon an eminence in the city, with his back to the sun and his face to the sea, beholds in the water, as in a catoptric theatre, various multiplied objects, *i. e.* an indefinite series of pilasters, arches, castles well-delineated, regular columns, lofty towers, superb palaces with balconies and windows, extended alleys of trees, delightful plains studded with herds and flocks, multitudes of men on foot and horseback, with many other strange images, all in their natural colours and proper actions, passing rapidly in succession along the surface of the sea during the short period of time while the above-mentioned causes remain. But if, in addition to the circumstances described, the atmosphere be highly charged with vapour and dense exhalations, it then happens that in this vapour, as in a curtain extended along the channel to the height of about thirty palms, and nearly down to the sea, the same objects are beheld not only reflected from the surface of the sea but likewise in the air, though less distinct and well-defined. Lastly, if the air be slightly hazy and opaque, and at the same time dewy and adapted to form the iris, then the above-mentioned objects will appear only at the surface of the sea (as in the first case), but all vividly coloured, or fringed with red, green, blue, and other prismatic colours." It is further shown by Minasi, from observations of the coast and town of Reggio, that the images of the Fata Morgana are derived from objects on shore. He tells us that he had beheld this magnificent spectacle three times; and although his account of it and those of other writers differ considerably from each other, these variations are only such as may be attributed to different conditions of the atmosphere at the time of the respective observations. That some of these descriptions may have received a certain degree of embellishment from the imagination, is not improbable; but there is certainly no reason to impugn—as some have done—their general accuracy. It may be observed, however, that the remarks of Minasi upon the causes of the several phenomena of the Fata Morgana are more fanciful and ingenious than satisfactory. It seems that the phenomenon in question appears to depend upon the calmness of the sea, and one or more strata of superincumbent air differing in refractive and consequently in reflective power; and that the confined situation of the sea in the Straits of Messina is peculiarly favourable to the development of the exciting causes of the phenomenon. For a more particular account of the Fata Morgana, the reader is referred to *Nicholson's Journal*, vol. i. 4to, p. 225, &c. Similar in character is the mirage observed in the great sandy plains of Persia, of Asiatic Tartary, in Lower Egypt, and on the plains of Mexico, &c.

In the *Philosophical Transactions* there is an account of a very singular instance of atmospheric refraction which occurred at Hastings, when the coast of Picardy, which is between 40 and 50 miles distant from that of Sussex, appeared close to the English shore. The sailors and fishermen, in amazement, crowded to the beach, and at length began to recognize several of the French cliffs, and were able to point out places they had been accustomed to visit. From the summit of the eastern cliff the spectator at one glance could see Dungeness, Dover cliffs, and the French coast all along from Calais to St Valéry; or as some affirmed, as far to the westward as Dieppe; and by aid of the telescope elevated objects on the French coast, such as buildings and trees, were readily discerned.

FATALIST, one who maintains the doctrine that all things are subject to a predetermined fate, or that all events are the result of an inevitable necessity, and therefore cannot be influenced by any choice or effort of man. See METAPHYSICS, § *On Necessity;* PREDESTINATION; MOHAMMEDANDISM, § 1.

FATE. See METAPHYSICS, and PREDESTINATION.

FATES, in *Mythology*. See PARCÆ.

FATHEMITES, or FATIMITES, the descendants of Mohammed by his daughter Fatima.

FATHER. See PARENT.

FATHER, in *Theology*, the first person in the Trinity. *Father*, as a title of honour, is given to dignitaries of the church, superiors of convents, Popish confessors, &c.

FATHERS, the name usually given to the principal writers of the early church. Those who were contemporary with the apostles, and are supposed to have been their disciples, are called Apostolic Fathers. Their works are not numerous, and they have unfortunately come down to us in a state which renders them very little worthy of confidence. The genuineness of some of them has been justly suspected, because it is well known that writings were forged in their name for the purpose of giving authority to particular doctrines or rites; and there can be no doubt that even their genuine writings were interpolated to promote the hierarchical interest which arose in the church.

The earliest of the writings ascribed to the Apostolic Fathers is the apocryphal epistle which, in the second century, was known in the Alexandrian Church under the name of BARNABAS, the companion and fellow-labourer of the apostle Paul. The design of this epistle was to diminish the respect which the Judaizing members of the church entertained for the peculiar institutions and rites of the Mosaic economy, and to show that these were not binding upon Christians. It does not contain any hint that the author wished to have it supposed that he was Barnabas; and the spirit and style of the epistle indicate that the writer was a Jew of the Alexandrian school who had embraced Christianity.

Next to Barnabas we place CLEMENT, who was bishop of the church at Rome about the end of the first century, and is believed to be the same Clement whom Paul (Philip. iv. 3) calls his fellow-labourer, and one of those whose names are in the Book of Life. The "Epistle of the Church of God sojourning at Rome to the Church of God at Corinth," which

bears the name of this father, was written about the year A.D. 96, and has been termed the most important monument of this apostolical age remaining to us, and is probably the most ancient of uninspired Christian writings. It was held in such high respect during the first centuries that it was read at public worship in many of the churches along with the scriptures of the New Testament. The object of the writer was to allay some internal dissensions in the Corinthian church, and to conciliate the minds of the people to their pastors, some of whom they had expelled from their offices, undeservedly as Clement asserts, and had thereby introduced much confusion into the church. This epistle is genuine in the main, but it has been subjected to several important interpolations. A portion of what is termed a second genuine epistle of Clement has been preserved, but it is manifestly only the fragment of a homily. Two other epistles ascribed to this father, and termed Recognitions, have been preserved in the Syrian Church. They are circular letters addressed particularly to those Christians of both sexes who lived in the state of celibacy. These epistles, however, are found nowhere cited before the fourth century, and they bear every mark of having been forged in some Eastern church about the close of the second or during the course of the third century.

Under the name of HERMAS (whom some suppose to be the same as the person mentioned in Paul's epistle to the Romans (chap. xvi. 14) we have a work entitled "The Shepherd," because in the second book an angel, the appointed guardian of Hermas, is introduced in the character of a shepherd. The work, which was written originally in Greek, but has been preserved for the most part in a Latin translation, was held in high repute among the Greek writers of the second century, and is cited by Irenæus under the title of "The Scripture." "It consists of three books, in the first of which are four visions, in the second twelve commands, in the third ten similitudes. The first and third parts are very fanciful, yet they were not perhaps unsuited to the genius of the countries and age to which they were addressed; the second contains some excellent moral precepts, and all abound with paraphrastical allusions to the books of the New Testament."

IGNATIUS, bishop of the church at Antioch, during the journey to Rome which, according to tradition, terminated in his martyrdom, is said to have written seven epistles—six to the churches in Asia Minor, and one to Polycarp bishop of Smyrna. Five other epistles, which were for some time received as his composition, are now admitted to be spurious; and even the seven genuine epistles have been grievously corrupted and interpolated. These interpolations have evidently been made by some zealous partisans of the priesthood, for the purpose of unduly exalting the episcopal dignity. In the epistle to Polycarp it is said, "Attend to the bishop that God may attend to you. I pledge my soul for those who are subject to the bishop, presbyters, and deacons. Let my part in God be with them." "All of you," says the epistle to the Church of Smyrna, "obey the bishop as Christ obeyed the Father, and the presbytery as you would reverence the apostles, and the deacons as the commandments of God. Wheresoever the bishop may appear, there let the multitude assemble; even as the Catholic Church is there where Christ Jesus is. It is not lawful either to baptize or to celebrate an *Agape* without the bishop, but whatsoever he shall approve that is likewise well-pleasing to God." Again—"He who honours the bishop is honoured by God; he who acts without the knowledge of the bishop is in bondage to the devil." And the Ephesians are told that "it is their manifest duty to look up to the bishop as to the Lord himself." Statements such as these, inculcating upon the people the most unlimited and blind obedience to the hierarchical order, present such a marked contrast to the sentiments which had prevailed in the apostolic age, and which continued to prevail in the second century, that they can scarcely have come from the pen of Ignatius, who is supposed to have written about the sixteenth year of that century. A recent ecclesiastical historian, who is disposed to regard these and other similar expressions as genuine, accounts for them on the ground that it was the principal object of Ignatius to preserve the churches in strict union and discipline during the persecution which then threatened their destruction, by subjecting the faithful in rigid obedience to every order of their priesthood, but most especially to the highest. The days were then approaching, and were already come, he thinks, in which some severe system of subordination was absolutely necessary (under God's providence) for the preservation of the church.[1]

POLYCARP, bishop of Smyrna, who had been a disciple of the apostle John, according to Irenæus, wrote several epistles, but only one is now extant, addressed to the Church at Philippi. This epistle appears to have been written soon after the death of Ignatius, as it refers to his patience under suffering, and requests any information which the Philippians had obtained respecting him. It teaches the charitable spirit of Christian piety, and is valuable from containing many scriptural expressions and frequent quotations of the recorded words of Christ. It consists of thirteen sections, but the original Greek of the tenth, eleventh, and twelfth is lost, and they have been preserved in an ancient Latin version. As Polycarp suffered martyrdom in the reign of Marcus Aurelius, A.D. 167, in the ninetieth year of his age, his epistle to the Philippians was probably written before the middle of the second century.

Another class of the fathers of the church are the Apologists, who in the order of time immediately succeeded the Apostolical Fathers. The first of these is QUADRATUS, an evangelist or Christian teacher not connected with any particular church, but travelling about as a missionary to preach the gospel. His *Apology* has unfortunately not come down to us, but Eusebius has preserved the following remarkable passage from it:—

"The works of our Saviour were always to be seen, for they were real. Those that were healed and those that were raised from the dead were seen, not only when they were healed or raised, but they were always there; not only whilst he dwelt on the earth, but also after his departure, which they long survived, so that some of them have lived even to our own times."[2]

The first of the Apologists whose writings have come down to our times is JUSTIN MARTYR. He was a Samaritan by birth, and successively adopted the tenets of the Stoics, the Peripatetics, the Pythagoreans, and the Platonists, probably not so much from a taste for speculative inquiries, as from a longing after some stable ground of religious conviction. Having discovered by experience the insufficiency and emptiness of these systems of philosophy, he seems to have been attracted to Christianity by the courage and constancy with which its adherents endured the sufferings inflicted upon them by their persecutors.

"I was once," says he, "an admirer of the doctrines of Plato, and I heard the Christians abused; but when I saw them meet death and all that is accounted terrible among men without dismay, I knew it to be impossible that they should live in sin and lust. I despised the opinion of the multitude. I glory in being a Christian, and take every pains to prove myself worthy of my calling."[3] The conversion of Justin Martyr is supposed to have taken place about the year 133

[1] Waddington's *History of the Church*, vol. i., p. 61.

[2] Euseb., lib. iii., chap. 37; iv. 3; v. 17. Neander, *General Church History*, vol. ii., p. 444.

[3] *Apology*, i., pp. 50, 51.

Fathers.

A.D. He wrote two Apologies for Christianity; the first addressed to Antoninus Pius, the second probably to Marcus Aurelius. They are valuable compositions, not only because they contain the most convincing arguments which had then been published in defence of Christianity, but also because they give numerous quotations from the four Gospels, and relate many interesting facts respecting the religious customs and ceremonies of the Christians of those early ages. Next to the Apologies, the largest and most important work of Justin is his *Dialogue with Trypho the Jew*. The object of this treatise is to prove that Jesus is the Messiah predicted and promised in the Old Testament Scriptures, and to vindicate the doctrines of Christianity against the objections of the Jews. It contains a good deal of useful matter, mixed up, however, with not a few weak arguments, as well as trifling and even erroneous interpretations of Scripture. It is probable that it was composed at a later period than either of the *Apologies*. Another production which bears his name is entitled an *Admonition to the Gentiles*. Its design is to convince the heathen of the insufficiency of their popular mythology as well as of their philosophical doctrines, and of the necessity of a divine revelation. It is supposed to be the same treatise which is cited by Eusebius and Photius under the title of *The Refutation*. *A Short Address to the Gentiles* is ascribed to Justin, but it differs from the style of his genuine writings, and its title is not to be found in the ancient indexes to his works. His book against Marcion, and a work which he wrote against all the heretical sects of his day, have both perished. The fragment of a treatise on the Resurrection was published under the name of Justin, by John of Damascus, in the eighth century, but its genuineness is extremely doubtful. The letter to Diognetus on the characteristics of the Christian worship compared with paganism and with Judaism, which is found among the works of Justin, has been classed, on high authority, among the finest remains of Christian antiquity. Its style and turn of thought, however, as well as the silence of ancient writers, prove that it could not have come from his hand, although it bears unmistakeable evidence of high antiquity.

After the death of Justin Martyr, TATIAN of Assyria, who had been educated a heathen, and was converted by him during a visit which he made to Rome, wrote a discourse to the Gentiles, in which he vindicates the "philosophy of the barbarians" against the contempt of the Greeks, who, nevertheless, had received from them originally the germs of all science and arts. He was followed by Athenagoras, who addressed his apology to the emperor Marcus Aurelius and his son Commodus. A work from the pen of Athenagoras, in defence of the doctrine of the Resurrection, has come down to our day. THEOPHILUS, bishop of Antioch, in the reign of the emperor Commodus, wrote an apologetical work in three books, which displays great learning and power of thought. He also wrote a treatise against Marcion and Hermogenes, and composed commentaries on various portions of the sacred scriptures.

The most prominent of the Apologists next to Justin Martyr was IRENÆUS, who was bishop of Lyons about the year 178 A.D. His principal work is his *Refutation of the Gnostic System*, in five books, which contains a confutation of most of the errors which had then appeared in the church. It has come down to us, for the most part, only in the old Latin translation, together with some fragments of the Greek original. Many of the writings of Irenæus are known to us merely by their names. Two of his epistles possess an historical interest on account of their object. One of these is supposed to have been addressed to Blastus, who was probably a presbyter in the Church of Rome, and who had occasioned a division in that church, by adhering to the custom of Asia Minor with regard to the time of holding Easter. The other epistle was addressed to Florinus, a presbyter with whom Irenæus in early youth had enjoyed the society and instructions of the venerable Polycarp, and who appears to have taught that God was the author of evil. "These doctrines," says the venerable writer, in his appeal to his former companion, "the elders who preceded us, who associated also with the apostles, did not teach thee; for while I was yet a boy, I saw thee in company with Polycarp in Asia Minor; for I bear in remembrance what happened then better than what happens now. What we have heard in childhood grows along with the soul, and becomes one with it: so that I can describe the place in which the blessed Polycarp sat and spake—his going in and out—his manner of life, and the shape of his person—the discourses which he delivered to the congregation—how he told of his intercourse with John, and with the rest who had seen the Lord—how he reported their sayings, and what he had heard from them respecting the Lord, his miracles and his doctrine. As he had received all from the eye-witnesses of his life, he narrated it in accordance with scripture. These things, by virtue of the grace of God imparted to me, I listened to even then with eagerness, and wrote them down not on paper, but in my heart; and by the grace of God I constantly bring them up again fresh before my memory."[1] All the writings of Irenæus which have come down to us display the peculiarly practical character of his mind in his mode both of conceiving and treating the doctrines of the gospel; and while they manifest his zeal for the great fundamental truths of our holy faith, they at same time show his sincere aversion to religious dissensions, and his moderation and liberality of mind in all controversies about unessential matters.

HIPPOLITUS, one of the disciples of Irenæus, according to Photius, occupied an important place among the ecclesiastical writers belonging to the first half of the third century. But unfortunately, only a few fragments of his works remain. From the list of his writings given by Eusebius and Jerome, it appears that, besides homilies, he composed treatises on a variety of subjects, exegetical, dogmatical, polemical, and chronological. For an account of the later fathers of the church, see articles under their names.

(Neander's *General Church History*, vol. ii.; Waddington's *Church History*, vol. i.; Campbell's *Lectures on Ecclesiastical History*.) (J. T—R.)

Fathom || Faun.

FATHOM, a measure of length containing six feet. It is chiefly used for regulating the length of cables and cordage, and to ascertain the depth of water and mines.

FAUN (in Latin *Faunus*), the name given in the Roman mythology to a class of deities or genii supposed to inhabit the forests and groves, and who were particularly reverenced by husbandmen. The fauni correspond to the Greek *panes*, and are confounded by the Roman poets with the satyrs, which chiefly differed from the panes and fauni by the want of horns. The fauns are usually represented as of human form, but with the tail of a goat, pointed ears, short horns, and a flat turned-up nose; sometimes with the feet of a goat; and generally clothed in the shaggy skin of some beast. They delighted more particularly in vineyards; and are frequently described as wearing crowns of ivy or of vine-leaves, because, like the satyrs, they belonged to the train of Bacchus. The poets describe them as of a half-brutal nature, and devoted to pleasure and sensuality;—a character strongly impressed on most of the ancient statues of fauns that have come down to us. Among the most celebrated of these are—the old faun dancing, in the Florentine museum—the young faun playing on a flute—and the sleeping faun, now in the gallery at Munich. These rural deities were regarded as the descendants of Faunus, one of the early kings of Latium, who in later times

[1] Euseb., lib. v., chap. 20.

was worshipped as presiding over fields, herds, and shepherds, and also as an oracular divinity. He is thus identified with the Greek Pan—the Mendes of the Egyptians. The festival of the Faunalia, celebrated on the fifth of December by the country people, had reference to Faunus as the protector of agriculture and cattle; and sacrifices were also offered to him at Rome on the ides of February. In his prophetic capacity he was supposed to reveal the future to man, partly in dreams, and partly by mysterious voices in certain sacred groves, one near Tibur, around the well Albunea, and another on the Aventine mount.

FAUNA, in *Mythology*. See Bona Dea.

FAUNA (from *Faun*), in natural history, a collective word, signifying all the animals of a particular region or country, and also a description of them; corresponding to the word *flora* in respect of plants.

FAUNALIA, in *Antiquity*, a rural festival celebrated by the Romans with great rejoicing on the nones or 5th of December, in honour of the god Faunus, as presiding over agriculture, herds, and flocks. See Faun.

FAUSTINA, wife of Marcus Aurelius, Emperor of Rome, A.D. 138–160, was the daughter of Antoninus Pius and his wife Faustina Augusta. She was the mother of Commodus—a son not unworthy of his maternal descent. Faustina was distinguished equally for her beauty and her licentiousness; and as cruelty usually accompanies sensuality when invested with power, she has been accused of causing the death of her son-in-law Verus, and with encouraging the rebellion of Avidius Crassus. These charges rest on no good foundation, but her infamy is upon record. Aurelius affected to be insensible to the irregularities of Faustina. He advanced her paramours to public employments, and on her death obtained for her divine honours. Her statue was placed in the temple of Venus; and the village in Cappadocia where she died was erected into a city with the name of Faustinapolis. This, as M. Crevier says, is carrying goodness *too far*. It was either weak credulity, or vain dissimulation; but the subsequent conduct of Marcus Aurelius, in admitting his son Commodus to the imperial power while he was yet a boy, evinced an equal want of judgment and dignity.

FAUSTUS. See Fust.

FAVERSHAM or Feversham, a municipal borough and market-town of England, county of Kent, 9 miles W.N.W. of Canterbury. It is governed by a mayor, 4 aldermen, and 12 councillors, and in 1851 contained 4595 inhabitants. The town is very ancient, and obtained from several of the early monarchs various charters and privileges, especially as regarded the judgment and punishment of offences committed within its own jurisdiction. The town consists of four principal streets, forming an irregular cross, in the centre of which is the town-hall and market-place. The parish church is a spacious cruciform structure, surmounted by a tower and spire. Faversham has a free grammar-school, national school, theatre, and assembly-rooms. Faversham Creek, which communicates with East Swale, is navigable for vessels of 150 tons up to the town. On 31st December 1853, 308 vessels of 15,300 tons aggregate burthen belonged to the port; and during that year 1532 vessels of 116,381 tons entered, and 1478 vessels of 44,983 tons cleared at the port. Market-days, Wednesday and Saturday. The oyster fishery is extensively carried on. There are several powder-mills in the vicinity, but the government mills have been discontinued.

FAVIGNANA, the ancient *Ægusa*, one of the Ægates or goat islands, lies off the W. coast of Sicily, 11 miles S.W. of Trapani. It is 6 miles in length from E. to W., by about 2 in breadth, and contains about 4000 inhabitants. The surface is low, but it is intersected from N. to S. by a range of hills, on the highest point of which, near the centre of the island, stands St Catherine's Castle. It has extensive tunny and anchovy fisheries, and an export trade in sheep, goats, poultry, &c.

FAVISSÆ, in *Antiquity*, underground reservoirs or cellars near a temple, where water was kept, or in which were deposited broken vessels and other things of no further use in the services of the temple.

FAVONIUS, the Latin name of the west wind; also called Zephyrus.

FAVORINUS or Phavorinus, a celebrated sophist, who flourished during the reign of Hadrian. He was a Gaul by birth, being a native of Arelate (Arles) in the south of France; but at an early age he left his native place, and travelling through Greece and Italy, mastered the languages and literature of these two countries. His extensive knowledge, combined with great oratorical powers, raised him to eminence both in Athens and Rome, where he lived on intimate terms with the leading literary men and philosophers of the day. Plutarch dedicated to him his treatise on Cold, and Herodes Atticus was made the legatee of his excellent library after his death. He enjoyed for a while the favour and protection of the emperor, with whom, however, he subsequently quarrelled. He used to boast that, though a Gaul, he could speak and write Greek; that though he had offended the emperor, he still continued to live; and that though a eunuch, he had been charged with adultery. The titles of some of his works, which comprised biography, philosophy, and history, have been preserved; but of the works themselves, the remains are not sufficient to afford the means of fairly testing their value.

FAWKES, Francis, a poet and translator, was a native of Yorkshire, and born in the year 1721. He studied at Jesus College, Cambridge; and entering into holy orders, was successively curate of Croydon, vicar of Orpington, and rector of Hayes, and finally was made one of the chaplains to the Princess of Wales. He published a volume of poems in 1761, but derived more fame from his translations of the minor Greek poets—Anacreon, Sappho, Bion and Moschus, Musæus, Theocritus, and Apollonius. These classic versions by Fawkes are still our best. We may safely predict, however, that when his translations are forgotten, superseded by more spirited versions, Fawkes will still be remembered for his fine song, *Dear Tom, this brown jug that now foams with mild ale.* This learned and jolly clergyman died on the 26th of August 1777.

FAWN, a young deer: a buck or doe of the first year.

FAYAL, one of the Azore Islands. See Azores.

FAYOUM, a province of Egypt. See Egypt.

FE, Fo—or Fohi, the chief god of the Chinese, whom they adore as the sovereign of heaven. He appears to be the same as the Ceylonese Bhudd. They represent him as shining all in light; with his hands concealed under his robes, to show that his power does all things invisibly. He has at his right hand the famous Confucius; and at his left Lao-Kieon, chief of the second sect of their religion.

FEALTY (*fidelitas*), in *Feudal Law*, denotes the oath taken by a tenant on his entry, to be true and faithful to the lord of whom he holds his land. Fealty bound the tenant to fidelity, the breach of which was the loss of his fee. All lands being held either mediately or immediately of the crown, fealty is commonly divided into general and special; the former, that due by a subject to his sovereign the latter, that which is due by a tenant to his immediate superior. Fealty is incident to every manner of tenure except tenures at will and frank-almoign, though it chiefly belongs to copyhold estates held in fee and for life. The law as to fealty continues unchanged, though the oath of fealty is now rarely or never exacted.

FEAR, a painful emotion or passion, excited by the apprehension of impending evil, and attended with a desire of avoiding it. It is used in Scripture for awe, reverence,

veneration; as in the expression—"The fear of the Lord is the beginning of wisdom."

Fear was deified by the Pagans. Tullius Hostilius introduced the worship of this deity at Rome; and the Ephori of Sparta erected a temple to Fear near their tribunal, in order to strike awe into those who approached it. Fear was likewise worshipped at Corinth and elsewhere.

FEAST, according to modern usage, is the homelier term for a banquet, an occasion of good eating and drinking, generally assembling a number of guests. Two or three centuries ago, however, it was used to signify an occasion of religious joy and thanksgiving, and it is still thus used in our Bibles and Prayer-Books. The word is formed from the Latin *festum*, which some derive from *feriari*, to keep holiday; though others, as Vossius for example, derive it from the Greek ἑστιάω, *I feast* or *entertain*, from ἑστία, *hearth*, or *fire*. As a time of rejoicing in England is generally celebrated chiefly by partaking of good cheer, it is easy to see how the original usage of the word has been superseded, and the word festival has been introduced as the more common term for a day of religious rejoicing.

Almost every religion, true or false, ancient or modern, has had its solemn feast days. They were divinely appointed among the Jews, who were directed to congregate at Jerusalem three times a year for the solemn celebration of the feast of the Passover, or of Unleavened Bread, the feast of Weeks, and the feast of Tabernacles (see Deut. xvi.), on which occasions they were to "rejoice before the Lord."

The ancient Greeks were similarly accustomed to congregate for the celebration of great religious solemnities; and as their gods gave peculiar sanction to recreation, the religious observances were followed by gymnastic exercises of various kinds. Hence arose those great festivals known to us as the Olympian, Pythian, Isthmian, and Nemæan games, which at a very early period drew together the Greeks of every name and country at stated periods. In process of time they had many others.

The Romans also had numerous stated feasts in honour of their deities and heroes; as the Saturnalia, Cerealia, Lupercalia, Liberalia, Neptunalia, Consualia, Portumnalia, Vulcanalia, Palilia, Divalia, and others. They had also feasts instituted occasionally, as Carmentalia, Quirinalia, Terminalia, Floralia, Compitalia, Lemuria, Vernalia; besides other moveable and occasional ones, to give thanks to the gods for benefits received, to implore their assistance, or to appease their wrath, as the Paganalia, Feralia, Bacchanalia, Ambarvalia, Amburbalia, Suovetaurilia, and various others, denominated *feriæ;* as Sementinæ, Latinæ, &c. The feasts were divided into days of sacrifice, and days of banqueting; days of games, and days of rest or *feriæ*. As there was but little history written, or at least published, in those days, one object of these feasts was to preserve the remembrance of past occurrences.

The Mohammedans, besides their weekly feast or Sabbath, which is observed on Friday, have two solemn feasts, the first of which is called the Feast of Victims, and celebrated on the tenth day of the last month of their year; and the second is called Bairam. The Chinese have two solemn annual feasts in memory of Confucius; besides others of less note on various days of the year.

The feast days of modern Christendom include all Sundays in the year, and certain week-days in commemoration of the nativity, the circumcision, and the ascension of our Lord; the annunciation and the purification of the Virgin; the epiphany or manifestation of Christ to the Gentiles: besides one devoted to the memory of each of the principal apostles and evangelists; one to St Michael and all angels; one to the Holy Innocents; and one to include all saints in general. These week-days are not only feasts but *feriæ* wherever the Roman Catholic religion has full sway. On the other hand, the Presbyterian and other nonconforming churches take no notice of them whatever. As to the time of their celebration, the feasts of the Christian church are said to be moveable or immoveable. The *moveable feasts* are always celebrated at a certain interval of time before or after Easter Sunday, which, to conform it to the time of the Passover, is kept on the first Sunday after the first full moon that happens on or after the 21st of March. The *immoveable feasts* are those which are celebrated always on the same day of the year.

The prodigious increase of festival days in the Christian church commenced towards the close of the fourth century, and was occasioned by the discovery which was then made of the remains of martyrs and other holy men, in commemoration of whom they were established. But instead of being set apart for pious exercises, these festivals were spent in indolence, voluptuousness, and criminal indulgences. Many of them were even instituted on pagan models, and perverted to the most scandalous purposes. (For a particular account of religious festivals in England, see *Historia Sacra, or the Holy History*, giving an exact and comprehensive account of all the feasts and fasts of the Church of England; 2d edit., 8vo, London.)

Feasts of the Ancients. In the *Odyssey* (b. i.) we read of two kinds of feasts; the one called *eilapine*, given by a single host; the other called *eranos*, which was of the nature of a club, in which each guest shared the expense. At the former kind there were—1st, the proper guests; 2d, the *shadows*, or those brought in by the invited guests; 3d, the *parasites*, a kind of sponging buffoons who came in without any invitation. Among the Greeks it was not the custom to invite women; but it was otherwise with the Romans. As soon as the guests arrived at the house of their host, their sandals were removed by slaves, and their feet washed and anointed. It would appear that in the Homeric age it was the custom to *sit* at meals; but the recumbent posture was afterwards adopted, and the guests were arranged around the table on couches. Two persons usually reclined on each couch; or three among the Romans; but the number varied. (The manner of reclining at table is described under Accubation.) In eating, as the luxury of knives and forks was unknown, the Greeks made use of their fingers; but they used spoons in partaking of soup and other liquids. The distributor gave to each guest his proper portion of the viands, which were cut beforehand into small pieces. There were three courses. The first consisted of such things as were calculated to whet the appetite, though this was rather a refinement of the Romans; the second or principal course then appeared; and this was followed by the dessert, at which the delicacies were produced. The tables (which were not covered with cloths as with us) were wiped with sponges after each course. Water for washing the hands was also handed round, but every person brought his napkin with him. The guests arrayed themselves in white garments, wore chaplets of flowers on their heads, and often anointed the hair and beard with fragrant oils. The banqueting-room, too, was decorated with garlands of roses, which were suspended above the table as the emblem of silence or secrecy; and hence the phrase, to utter a thing *sub rosa*. All the requisites for the entertainment were provided by the *symposiarch*, or master of the feast, who was either the host himself or a person of his selecting; and the *king* of the feast, or *arbiter bibendi*, presided over the drinking. The cupbearers (generally beautiful boys) presented the wine in goblets, which were frequently of exquisite workmanship, and decorated with wreaths. The luxurious Romans drank out of cups made of crystal, amber, or the costly porcelain called *murrha*, as also of onyx, beryl, and richly-chased gold set with precious stones. The wine, which was usually much diluted with water, was mixed in a large vessel called a *crater;* and from that it was transferred to the goblets by

means of a *cyathus* or ladle. It was customary to introduce the drinking by making a libation of unmixed wine to the "Good Genius;" and this ceremony was usually accompanied with the singing of the *pæan*, and the playing of flutes. Then the mixed wine was produced, and the first cup was drank to "Jupiter the Preserver." The number of cups was regulated sometimes by that of the Graces, or more frequently by that of the Muses; yet even this number was often exceeded—for it was not unusual both to drink all round, and also to the health of absent friends and mistresses, besides as many cups as the name contained letters. In this, however, and likewise in other particulars, banquets differed with the character of the guests; for a symposium of young men and one of philosophers and statesmen had different kinds of entertainment. The *symposia* of Plato and Plutarch give us a lively idea of such entertainments. From them we learn that, besides the conversation, which was sometimes of a serious and philosophic cast, but frequently consisted in sallies of wit and repartee, together with enigmas and riddles (a very favourite kind of amusement), they had also singing and other music. When the repast was ended, the flute-players, female singers, dancers, and buffoons, were introduced; or the guests themselves engaged in games of various kinds, among which the *cottabus* is famous. (See COTTABUS.) At the close of solemn and splendid feasts the distribution of the *apophoreta* took place, which were presents given by the host to his friends to take home with them.

FEATHERS, the peculiar exterior covering of birds, constituting what is called their plumage. Feathers vary in size, form, colour, and function, in different species, in the several parts of the same individual, and also in the same bird at different stages of its existence; and their exquisite adaptation to the several ends they are designed to serve has often been adduced as illustrative of creative wisdom. "The covering of birds," says Paley, "cannot escape the most vulgar observation: its lightness, its smoothness, its warmth, the disposition of the feathers all inclined backward, the down about their stem, the overlapping of their tips, their different configuration in different parts, not to mention the variety of their colours, constitute a vestment for the body, so beautiful and so appropriate to the life which the animal is to lead, as that we should have no conception of anything equally perfect if we had never seen it, or can now imagine anything more so."

Feathers, when analyzed chemically, seem to possess nearly the same properties with the hair of mammifers and the scales of reptiles; but they differ essentially from the integuments of these classes of animals in respect to mechanical structure—being much more complex in their constituent parts. The principal parts of an ordinary feather are the tube or quill, the shaft or stem, and the vane. The quill is a hollow semi-transparent cylinder composed of coagulated albumen, and is more or less protracted. It closely resembles a thin piece of clear horn, both in appearance and chemical constitution; while at the same time it combines, in an eminent degree, the opposite qualities of strength and lightness. The horny substance of the quill in many species is disposed internally in longitudinal fibres, while the outer part is composed of transverse or annular fibres. Hence the reason why, in making a pen, the slit is always cleanest when the exterior or annular layer has been scraped off. The dry and shrivelled membranous substance inclosed in the cavity of the quill forms part of an apparatus that has been subservient to the growth of the other parts of the feather, and consists of an imbricated series of conical capsules communicating with each other. The quill is also provided at each end with a small orifice (termed respectively the upper and the lower umbilicus) through which nourishment is conveyed to the other parts of the feather.

The shaft, which is a continuation of the quill, and composed of an attenuated pellicle of the same substance, gradually passes into a sub-quadrangular form, narrowing until it forms a point at the tip. The back is more or less convex for some distance from its origin, and the face is formed of two convex surfaces which are separated by a groove that runs along its whole length, or of two inclined planes meeting at an obtuse angle; while the lateral surfaces are more or less plane. The white medullary substance forming the interior of the shaft, is called the *pith*—a substance *sui generis*, and which supplies strength and nourishment to the feather.

The vane, or that part which gives the feather its breadth, consists of two webs (one on each side of the shaft), and is by much the most complicated of all its parts. The webs consist of a series of laminæ called *barbs* or *rays*, which are set obliquely to, and are composed of the same material as, the shaft from which they spring. The barbs are arranged in close apposition, with their broad surfaces towards each other—a disposition that enables them to offer very considerable resistance to being bent out of their plane, or that direction in which they have to encounter the impulse and pressure of the air, particularly in the act of flight; while it admits of their yielding readily to the slightest pressure in the line of the shaft. The barbs taper to a point towards the outer edge of the vane; but at their base they are broad, (particularly in the great feathers of the wing,) and slightly hollowed on one side and convex on the other. This conformation both gives strength to each individual barb, and also enables it to afford support to its neighbour. But the most complex part of the mechanism of the vane is the apparatus of *barbules*, by means of which the barbs are kept firmly in apposition. The barbules are minute filaments that proceed from the upper part or edge of each barb, in two sets, one on either side, and having a direction, with respect to the barb, similar to that of the barbs with respect to the shaft. Those on the side next the quill are shorter, more adpressed, and curved upwards at the extremity; those on the side next the tip of the feather are longer, more patulous, and curved downwards: and when placed in apposition they form two distinct and continuous edges, the incurvate or anterior series of one barb overlapping and hooking into the recurvate posterior series of the barb next to it; and in this manner they give the barb a closeness and compactness of texture that resembles the effect of glutinous cohesion. When this connection is disturbed by external violence, the barbules reclasp when the barbs are again brought into apposition. When the barbs are pulled asunder in the plane of the web, their cohesion is found to be very considerable in most feathers: when the posterior barb is pulled downwards out of the plane of the web, the cohesion is found still greater: but when the anterior barb is pulled downwards, or the posterior barb upwards, there is no cohesion at all. The barbules themselves are frequently complicated by a similar apparatus, giving off laterally two series of filaments called *barbicels;* but these are much more sparse than those of the barbs, though they appear to serve a similar end, namely, that of retaining the barbules in apposition. When this clasping apparatus is wanting, as in the ostrich, the barbules hang loose and separate, and the feather is then termed a *plume*. In some birds, as the emeu, two plumy feathers arise from one quill; or even three, as exemplified in the cassowary.

There is in feathers the following gradation in respect to division:—1st, a feather may consist of a quill and a shaft, without any other part; 2d, of a quill, a shaft, and barbs destitute of barbules, as in the crest-feathers of the golden pheasant; 3d, of a quill, a shaft, barbs, and barbules, as in most birds; 4th, of a quill, shaft, barbs, barbules, and barbicels, as in the quills of the ring-tailed eagle, the albatross, and helmet-hornbill. In most birds, each feather possesses a downy tuft, more or less developed, at the upper end of

the quill; and this is termed the *accessory plume.* In the cassowary this development is two-fold. In the feathers of many birds the downy part occupies by far the greater portion, while in others it scarcely exists. As an example of feathers all downy may be mentioned the subcaudal feathers of the peacock, and the abdominal feathers of the eagle-owl, &c. Of such as have very little down may be mentioned the different species of penguin. On the different parts of the body in many birds there exist feathers of a piliform character, resembling stiff bristly hairs. Besides the feathers now described, the bodies of many birds are closely invested (underneath the feathers proper) with a soft down, the warmth or lightness of which is generally proportioned to the habits of the species; being usually most dense in aquatic birds, as in the eider-duck. Each down-feather consists of an extremely delicate shaft, from which proceed, in general, two sets of finely ciliated filaments. Down also constitutes the first covering of young birds, previous to the development of feathers, which they guide as it were through the skin, in the same manner that the old feathers during the moult of full-grown birds serve as the *gubernacula* of the new. It may be observed generally, that in some species the down presents certain modifications of structure different from that now described, as in the case of other kinds of feathers. In most birds, after the feathers have been removed, we find a number of simple feathers resembling hairs. These are the hairs singed off in a common fowl after it has been plucked. In the common pheasant their structure is as follows:—from a very short bulbiform tube rises a very slender roundish piliform shaft, somewhat resembling a hair of the human head, but much smaller and straight, and giving off at its extremity two or three short simple barbs on either side.

Every feather may well be said to be "a mechanical wonder," when we consider the perfection of its parts and the mechanism employed in its formation—the vessels that secrete the fluid material, and the moulds and capsules by which the process of formation is conducted, until the period when the protecting sheath gradually withers and crumbles away, leaving the young feather to unfold its beautiful and complicated structure. Ornithologists give special names to the feathers of the different parts of the body, indicative of their position or particular function; but an enumeration of these would be of little interest to the general reader, and may be found in any elementary treatise on ornithology.

As intimately connected with the plumage, it should be noticed that the feathered race generally are provided with a kind of oiling apparatus, situated at the base of the tail, and consisting of a double gland with a pore, filled with an unctuous matter, which the bird expresses by means of its beak and distributes over its feathers, thereby rendering them impervious to moisture.

As to the colours of the plumage, the variety is almost infinite, presenting every gradation from the most sombre shade and purest white to hues that rival in brilliancy the richest gems or the most gorgeous flowers; as in the humming-bird, creeper, and sun-bird. The feathers of young birds rarely exhibit the colours they are destined to assume at a later period: the livery of the female too is generally less lively, and sometimes altogether different from that of the male bird: and sometimes the summer plumage is quite distinct from that of winter. Moulting usually takes place after the female has laid her eggs, (with less regularity in the domesticated birds), and is characterized by the dulness and roughened aspect of the plumage, and the temporary loss of voice among singing birds.

Uses to Man.—Feathers make a considerable article of commerce; particularly those of the ostrich, heron, swan, eider-duck, peacock, goose, common domestic fowl, &c., which are used for plumes and ornaments, beds, pens, &c. It has often been said that living geese are plucked in some parts of Great Britain several times a-year; but we believe that this barbarous practice is by no means general, though it still exists in some places, as in Lincolnshire, and in the north of Ireland. The Somersetshire feathers once had a high reputation, but no extra quantity has been produced there for a long period. The common method of curing small feathers, such as those used for bedding, is to expose them to the sun in a dry room, and then to put them in bags and beat them with poles, to remove all adhering extraneous particles; but this object is now effected much more perfectly by steeping the feathers in a chemical solution, and then washing and drying them gradually, so as to prevent them shrinking. The Greenlanders use the downy skin of the eider-duck as a protection against cold. The feathers of the ostrich are much prized as ornamental articles of dress; and the capture of these birds for the sake of their plumes affords employment to many of the inhabitants of the desert. Feathers are also occasionally applied to a variety of other ornamental purposes, not the least curious of them being that of forming pictures, in the manner of mosaic, of the splendid feathers of the humming-bird, though it must be admitted that the effect is by no means commensurate with the labour required for their production. The French and Italians are particularly skilful in fabricating feathers into beautiful imitations of flowers.

FEBRIFUGE, an appellation given to such medicines as serve to mitigate or remove a fever.

FEBRUARY, the second month of the year. In ordinary years it contains 28 days; but in bissextile or leap-year, by the addition of an intercalary day, it consists of 29 days. This month was not in the Romulian calendar. In the reign of Numa two months were added to the year, namely, January at the beginning, and February at the end; and this arrangement was continued until B.C. 452, when the decemvirs placed February after January. The ancient name of *Februarius* was derived from the verb *februare*, to purify; or from *Februa*, the Roman festival of general expiation and lustration, which was celebrated during the latter part of this month. In February, also, the Lupercalia were held, and women were purified by the priests of Pan Lyceus at that festival.

FÉCAMP, a seaport-town of France, department of Seine-Inférieure, situated on the English channel, at the mouth of a small cognominal river 23 miles N.N.E. of Havre. Pop. about 10,000. It occupies the bottom and sides of a narrow valley opening out towards the sea between two high cliffs, on one of which stands a lighthouse. Its port, though small, is one of the best on the channel, and has latterly been greatly improved by the construction of an inner port with a fine quay, &c. It carries on a considerable trade in Baltic and colonial produce, brandy, salt, &c.; and sends out vessels to the whale, cod, mackerel, and herring fisheries. The river affords abundant water-power for numerous cotton, oil, and other mills. Fécamp has also sugar refineries, tanneries, building docks, and manufactures of hardware, candles, soda, &c. The town consists almost entirely of one street upwards of two miles in length. The church, a large and handsome edifice, is the sole remains of a celebrated abbey founded towards the end of the tenth century, and destroyed during the Revolution.

FEDERAL, of or belonging to a league or covenant: a term usually employed to designate the government of a confederacy consisting of several united sovereign states. The principal purposes for which such a union is formed are, the protection of the common interests of the members, their defence against the attacks of foreign enemies as well as against internal convulsions, and the superintendence of their political and commercial intercourse with other nations, together with the regulation of the commerce between the confederated states themselves. To accomplish these

purposes, the federation must be invested with full power to levy troops, to build and equip fleets, to raise the money requisite for the support of an army and navy, to prescribe rules for their government, and to direct their operations. The members of the union must therefore surrender to the joint body certain sovereign powers which they have been accustomed to exercise in their several states. The interpretation of the contract which determines the extent of the powers to be surrendered must belong to the joint body; but it will be necessary for the protection of the rights of the various members against the encroachments of the federation, that any one party should be allowed to withdraw from the union at pleasure. The degree to which the sovereign states united under one federal government have given up their individual rights varies considerably. In some confederations there is no federal government, and the union between the various associated states is not closer than a mere treaty, offensive and defensive, would effect between two states. In others the government is invested with unlimited discretion to take measures for the common defence—to make requisitions of men and money—to govern the common army and navy, and to direct their operations; and the proceedings of the government are made constitutionally binding upon all the associated states, even without their unanimous consent. In the old Germanic empire, one member might wage war with another; in the Swiss confederation, the different states are allowed to conclude treaties with foreign powers, unless they are expressly prohibited by the constitution; while the confederated states of North America have surrendered among other things all political power in so far as it relates to foreign affairs. Professor Austin makes a distinction between a supreme federal government and a system of confederated states. The former enforces its commands in each and all of the associated states, whereas the latter, through their representatives or delegates, may assemble and pass resolutions which concern all the members of the confederacy, yet leave these resolutions to be enforced in each state by its own sovereign power. In this system, therefore, each of the several societies is an independent political society, and each of their several governments is properly sovereign or supreme. For an example of this system of confederated states, the professor refers to the German confederation, which has succeeded to the ancient empire. "I believe," he says, "that the present diet is merely an assembly of ambassadors from several confederated but severally independent governments; that the resolutions of the diet are merely articles of agreement, which each of the confederated governments spontaneously adopts; and that they owe their legal effect in each of the compacted communities to laws and commands which are fashioned upon them by its own immediate chief. I also believe that the Swiss confederation was and is of the same nature. If, in the case of the German or of the Swiss confederation, the body of confederated governments enforces its own resolutions, those confederated governments are one composite state rather than a system of confederated states. The body of confederated governments is properly sovereign: and to that aggregate and sovereign body, each of its constituent members is properly in a state of subjection."

The principal examples of this form of government have been the confederacy of the ancient Grecian republics, and in more modern times, the Germanic empire, the Swiss republics, and the United States of North America. There is conclusive evidence that several associations existed at a very early period among the Grecian states, for the purpose of repelling the attacks of their common foes, and of protecting the temple of their common deity. The most important of these confederations was the union of the twelve tribes, which constituted the AMPHICTYONIC LEAGUE. All the members of this confederacy retained the character of independent states, and, though some of them were very insignificant, had equal rights and equal votes in the federal council, which met twice every year, in the spring at Delphi, and in the autumn at Anthela, near the pass of Thermopylæ. The deputies who were sent to these meetings were appointed in their respective states by lot, and each state had two votes. The council was empowered to watch over the temple at Delphi, and to guard the immense wealth deposited there—to decide all controversies between the members of the league—to inflict a fine upon the aggressor—to employ the whole power of the confederacy to punish those who should disobey its mandates—to admit new members—to declare and carry on war, and generally to adopt whatever measures it deemed necessary for the common welfare of the confederation. The Amphictyons were bound by an oath mutually to protect and defend the associated states, and to inflict vengeance on those who should sacrilegiously despoil the temple of the deity whose worship formed the external bond of union among them. The objects of the Amphictyonic confederacy were no doubt wise and humane, but they were never adequately carried out, and in their active interference in the affairs of Greece the council showed themselves more influential for evil than for good. The more powerful members successively tyrannized over the weaker. There was no cordial co-operation among them even in the midst of the most dangerous defensive wars, and their mutual jealousies and incessant quarrels paved the way for the ruin of their liberties and independence.

Another confederacy of Grecian republics was the famous ACHÆAN LEAGUE, which dates from the year B.C. 280, though it did not rise into importance till about thirty years later. The states composing this league, as in the former instance, enjoyed a perfect equality. They retained their municipal jurisdiction, and appointed their own officers, but they had all the same laws and customs, the same weights and measures, and the same money, though it is uncertain whether this was the result of their own choice, or proceeded from the authority of the federal council. This council had the sole right of peace and war, of sending and receiving ambassadors, of entering into treaties and alliances, and of appointing a prætor or chief magistrate, who, with the advice and consent of ten of the deputies, administered the government in the recess of the council. At first the council had two prætors or presidents, who were nominated alternately by the different towns, and were associated in the administration, but after a short trial only one was elected. The union among the members of the Achæan League was much closer, and its organization more judiciously framed than in the case of the Amphictyonic confederacy. The united testimony of all the historians who have taken notice of its affairs, shows that the government of this federal league was administered with far greater justice and moderation; and the citizens of the various states under its superintendence were much less turbulent and seditious than in any of the cities of Greece which exercised singly all the prerogatives of independent and sovereign states. The popular government, says the Abbé Mably, which was so tempestuous elsewhere, caused no disorders in the members of the Achæan republic, because it was there tempered by the general authority and laws of the confederacy.

In later times, another example of a federal government was exhibited by the GERMANIC EMPIRE, the administration of which was vested in a representative diet, in the emperor to whom the powers of the executive were entrusted, and in two judiciary tribunals (the imperial chamber and the aulic council) which possessed supreme jurisdiction in all disputes among the members of the confederacy. To the diet was entrusted the general power of legislating for the empire—of making war and concluding peace—forming alliances—assessing quotas of troops and money—constructing fortresses—regulating the coinage—admitting new members,

and subjecting refractory members to the ban of the empire. To the emperor belonged the exclusive right to make propositions to the diet—to negative its decrees—to name ambassadors—to confer dignities and titles—to fill vacant electorates—to receive and disburse the public revenues, and generally to watch over the public safety. In certain cases he was assisted by a council formed of the electors. In theory this federal constitution seemed well fitted to gain the end for which it was framed; but experience has shown that it afforded no security either against external dangers or internal dissensions. "The history of Germany," it has been justly said, "is a history of wars between the emperor and the princes and states—of wars among the princes and states themselves—of the licentiousness of the strong, and the oppression of the weak—of foreign intrusions and foreign intrigues—of requisitions of men and money disregarded or partially complied with—of attempts to enforce them, altogether abortive, or attended with slaughter and desolation, involving the innocent with the guilty—of general imbecility, confusion, and misery."[1]

The United Provinces of the Netherlands were a confederation composed of seven co-equal and sovereign states, each of which consisted of several equal and independent cities. The sovereign authority was vested in the states general, consisting usually of about fifty deputies, who held their seats, some for life, some for a fixed limited period, and in two cases during pleasure. In all important matters, not only the provinces, but the cities, required to be unanimous. The executive magistrate was the stadtholder, to whom was entrusted the command of the army and navy, with authority to appoint all naval and military offices, to assist at the deliberations of the states general, and to settle all disputes between the provinces. The history of this celebrated confederacy has shown that its practice differed widely from its theory; and the mutual jealousies of its members, and the weakness of the government, ultimately brought the league to anarchy and dissolution.

The Swiss Confederation consists of twenty-two sovereign cantons, united for "the maintenance of their liberty, their independence, and security against any attacks from abroad, as well as for the preservation of order and tranquillity at home." For these purposes, a certain fixed contingent of troops is furnished by each canton whenever required, amounting in all to about 34,000, and the reserve, in case of need, to as many more. A pecuniary contribution for defraying the military and other general expenses of the confederacy is also paid by each canton in proportion to its property and resources. The diet consists of the deputies of the twenty-two cantons, who are chosen by their respective governments. It is entrusted with authority to declare war, to conclude peace, and to form alliances with foreign powers; and on these occasions three-fourths of the votes are necessary to constitute a majority. All other questions are decided by a simple majority. The diet also appoints the military officers and the diplomatic agents of the confederation, settles disputes among its members, acts the part of mediator in cases of internal disturbances within a canton; and, in general, takes all steps that may be deemed necessary for the safety of the country. No canton is allowed to go to war with another canton, and the diet may have recourse to arms to punish the violation of this or of any other fundamental law of the confederacy. The ordinary sessions of the diet, which last about five weeks, are held annually in the chief town of one of three vororts, or directing cantons, Zurich, Berne, and Lucerne, which hold the office of vorort by turn, for two years. The council or executive of the directing canton for the time being, along with its burgomaster, is entrusted with the management of the affairs of the confederation during the recess of the diet, but it is assisted in its duties by a federal chancery, consisting of a chancellor and a secretary, both appointed by the diet.

It will be evident from these statements, that the Swiss republics do not form one united state, but rather a confederation of states, having each their own peculiar constitution. They have, properly speaking, no permanent federal executive, and the diet is merely an assembly of delegates, who vote according to the instructions given by their constituents.

In this respect the Swiss confederacy differs widely from the United States of North America, which have a permanent executive, with a federal treasury and army and navy at its disposal. The federal legislature or congress consists of two bodies—a house of representatives chosen for one or two years, and a senate for a period varying from two years to six—the former by popular election, the latter by the representatives of the twenty-four states. The congress has power to provide for the common defence and general welfare of the United States—to regulate commerce with foreign nations and among the several states—to levy taxes and coin money—to declare war—to raise and support armies—to establish and maintain a navy—to provide for organizing, arming, disciplining, and calling forth the militia—to admit new members into the Union—to constitute tribunals inferior to the supreme court—to regulate and dispose of the territory or other property belonging to the United States; and, in general, to make all laws which may be regarded as necessary for carrying into execution the foregoing and all other powers vested by the constitution in the government of the United States, and to propose amendments in the constitution, which, however, shall not be held valid unless ratified by the legislatures of three-fourths of the several states.

The executive power is vested in the president for the time being, who holds his office for four years, but is occasionally re-elected for four years more. He is commander-in-chief of the federal army and navy, and of the militia when called into active service; and has power, with the advice and consent of the senate, to make treaties, to appoint ambassadors, the judges of the supreme court, and the other public ministers, consuls, and officers of the United States, whose appointments are not otherwise provided for by the constitution. He has a partial and temporary veto upon the measures adopted by congress. But if, on reconsideration of the bill objected to by the president, two-thirds of both houses adhere to their approval of the measure, it becomes a law.

A few amendments have been made on this form of government since its promulgation in 1798, but the constitution itself has stood the test of more than half a century, though exposed to several by no means inconsiderable dangers. In 1827, the constitutional right of congress to legislate for all the states of the confederation was called in question by South Carolina, Georgia, and Virginia. The cause of this hostility to the Union was the reduction of the tariff on foreign produce, which was vehemently opposed by these states; but a compromise on the part of the Union restored the good-feeling of the disaffected provinces, although the principle of nullification was left unsettled, and still continues to be so. The late violent discussions on the slave question have likewise been attended with the same hostility, and a threat to dissolve the Union.—(St Croix *des Anciens Gouvernements; The Federalist;* Vieusseau's *History of Switzerland.*) (J. T—R.)

FEE, in *Law*, the same as feud or fief, properly signifies a conditional stipend or reward, and is applied to property held of a superior on condition of rendering him service. An estate of inheritance is said to be in *fee-simple* when it is held in the freest manner, clear of any condition, limita-

[1] *The Federalist*, vol. i., pp. 114–116.

tion, or restrictions to particular heirs, and descendible to heirs general, whether male or female, lineal or collateral. Limited fees are such as are burthened and confined with conditions or qualifications; and these may be divided into two kinds, viz., *qualified* or *base fees*, and *fees conditional* or *fees tail*. A qualified or base fee is such as has a qualification annexed to it, and which must terminate when the qualification subjoined to it is at an end; *e.g.* an estate granted to A and his heirs, *tenants of the manor of Dale*, is determined whenever A or his heirs cease to be tenants of that manor. A conditional fee at common law was a fee restrained to particular heirs exclusive of others; as, to the heirs of a man's body, by which collaterals were excluded. In such case, if the donee had no heirs of his own body, the land reverted to the donor on the death of the donee; but if heirs were born, his estate became absolute and unconditional, so that he might aliene it, and thereby bar not only his own issue, but also the donor, of his reversionary interest. If, however, the tenant did not so aliene the land, the condition still remained in force; for if the issue had afterwards died without any alienation, the land, in terms of the donation, reverted to the donor on the death of the donee. This naturally gave rise to fictitious sales of land by tenants in possession, as soon as they had performed the conditions specified in the grant; so that on the reconveyance of the land into their hands they held it unconditionally, or in *fee-simple*. To abolish this practice, the statute of 13th Edw. I., cap. 1, commonly called the statute *de donis conditionalibus*, was passed, enacting that from thenceforth the will of the donor be observed, and that the land should go to the heirs specified, if there were any, or if none that it should revert to the donor. Thus the donee had no longer a conditional fee-simple which became absolute and at his own disposal the instant any issue was born; but the estate was divided into two parts, leaving in the donee a new kind of particular estate, denominated a *fee-tail*, and vesting in the donor the ultimate fee-simple of the land, expectant on the failure of issue; which expectant estate is termed a reversion. Estates tail are either general or special; the former being where lands and tenements are given to one, and the heirs of his body; the latter is where the gift is restrained to certain heirs of the donee's body; as where lands and tenements are given to a man and his heirs by his now wife. Estates in general and special tail are further diversified by the distinction of sexes in such entails, for either may be in tail male or tail female. See Entail.

FEEJEE or Fiji Islands, a group of islands in the South Pacific, lying between S. Lat. 15. 30. and 19. 30., and E. Long. 177. and 182., and forming part of the Friendly islands. The group comprises upwards of 150 islands, 65 of which are inhabited. They are of volcanic formation, are rich and fertile, and some of them are very mountainous. The productions are sugar-cane, cotton, coffee, cocoa-nut, bread-fruit, oranges, melons, citrons, olives, guavas, and sandal-wood. The natives are well formed and active, but warlike and cruel. The principal islands are Kantaon, Ovolau, Ambau, and Muthuatu. The Feejee islands were discovered by Tasman in 1643. Pop. estimated at 133,000.

FEITH, Rhynvis, a distinguished Dutch poet, was born at Zwolle, in Overyssel, in 1753. He studied law at Leyden, but not requiring to follow out that profession for a subsistence, he devoted most of his time to the study of art and polite literature. He rose to be burgomaster of his native town, and was afterwards appointed receiver at the Admiralty College. In 1779 he obtained a prize for a poem on the blessings of peace, and in 1781 the gold medal of the Leyden Poetical Society for a treatise on the essential characters of epic poetry. Of his tragedies the best is his *Iñez de Castro;* and his poem of *The Grave* is reckoned one of the best didactic poems in the Dutch language. Many of his occasional pieces are remarkable for purity of sentiment and loftiness of moral aim. He died in 1824.

FELEGYHAZA, a town of Hungary, capital of the district of Little Cumania, on the road between Pesth and Temesvar, 65 miles S.E. of the former. Pop. about 16,000. It has a Roman Catholic church, gymnasium, high school, and a court of justice, in which the archives of the district are preserved. It has also an extensive trade in corn, wine, fruit, and tobacco, and large cattle fairs are held here. Some Roman antiquities have been discovered in the vicinity.

FÉLIBIEN, André, Sieur des Avaux et de Javercy, a distinguished French writer on various departments of art, was born at Chartres in 1619. In his twenty-eighth year he was appointed secretary to the French embassy at Rome, and availed himself of his sojourn in that city to cultivate the acquaintance of the greatest living exponents of art, the most notable of whom at that time was his countryman Poussin. On his return home he was promoted to a number of important offices in connection with the arts and manufactures, and was made councillor and historiographer to the king. He died in 1695. His principal works are his *Entretiens sur les Vies et sur les Ouvrages des plus Excellents Peintres Anciens et Modernes*, 1666–88, 5 vols. 4to; *Principes de l'Architecture, de la Sculpture, et de la Peinture, avec un Dictionnaire des Termes propres de ces Arts*, 1676, 4to; and *Origine de la Peinture*, 1660, 4to.

His son, Jean François, inherited to a certain extent his taste for the fine arts, and enjoyed considerable fame as the author of the *Collection Historique des Vies et des Ouvrages des Architectes les plus Celèbres;* and also for his comparative view of ancient and modern Versailles.

FELICITAS, Felicity, or *Happiness*, was deified by the ancients. Lucullus consecrated a temple to Felicitas, as also did Lepidus. This goddess is generally represented on medals with a cornucopia in one hand and a caduceus in the other.

FELIS. See index to Mammalia.

FELIX, M. Minucius, a distinguished Roman lawyer, concerning whose era there has been much dispute. Some critics refer it to the middle of the second century after Christ, others to the time of Diocletian, while St Jerome, whose testimony may be taken as final, places him between Tertullian and Cyprian, and thus assigns him to the first half of the third century. He is now best known as the author of *Octavius*, a dialogue on Christianity between a Christian convert and a pagan. This work is deservedly entitled to rank high among the early apologies of Christianity. It is characterized throughout by an impressive earnestness of tone, and closeness and cogency of reasoning, while the style is as remarkable for precision and terseness as the diction for grace and purity. It was long imagined that the *Octavius* formed part of Arnobius' treatise *Adversus Gentes*, and it was not till 1560 that this mistake was discovered, and the work assigned to its rightful author by Balduinus. Since that date many editions of the work have appeared.

Felix, the name of several Roman pontiffs. Felix I. was chosen bishop of Rome in 271, and suffered martyrdom in 275. Felix II., sometimes styled III. on account of an anti-pope who assumed the former title, reigned from 483 to 492. Felix III., called also IV., succeeded to the papal throne in 526, and died in 530. A detailed account of Amadeus VIII., Count of Savoy, who became pope under the title of Felix V., is given under Amadeus.

FELLENBERG, Emanuel von, a celebrated educationist, was born in 1771 at Berne, in Switzerland. His father was of patrician family, and a prominent public man in his native canton, and his mother was a grand-daughter of the celebrated Dutch admiral Van Tromp. In both of his parents he was peculiarly fortunate, and to the tender and pious care of his mother he used to attribute the suc-

cess of his efforts for the public good in after life. From her and from Pfeffel, the blind poet of Colmar, he received a better education than falls to the lot of most boys, while the intimacy of his father with Pestalozzi gave to his mind that bent which it afterwards followed. As soon as he was able he began to make it the object of his life to investigate thoroughly the social and moral condition of his countrymen, and, in so far as he could, to improve it. For this purpose he spent much of his time in travelling through Switzerland, usually on foot, with a knapsack on his back, visiting the hamlets and farm-houses, mingling in the labours and occupations, and partaking of the rude fare and lodging of the peasants and mechanics, and often extending his journeys into the adjoining countries. In 1790 he went to Tübingen, where he distinguished himself by his rapid progress in legal studies. After the downfall of Robespierre, he went to Paris and remained there long enough to be assured of the storm impending over his native country. This he did his best to avert, but his warnings were disregarded, and Switzerland was lost before any efficient means could be taken for her safety. Fellenberg, who had hastily raised a levy *en masse*, was proscribed, a price was set upon his head, and he was compelled to fly into Germany. He was shortly afterwards recalled however by his countrymen, and sent on a mission to Paris to remonstrate against the rapacity and cruelty of the agents of the French republic. But in this and other diplomatic offices which he held for a short time, he was witness to so much corruption and intrigue that his mind revolted from the idea of a political life, and he returned home with a view to devoting himself wholly to the education of the young. With this resolution he purchased the estate of Hofwyl, near Berne, intending to make agriculture the basis of a new system which he had projected—for elevating the lower and rightly training the higher orders of the state, and welding them together in a closer union than had hitherto been deemed attainable. His scheme at first excited only the ridicule of his friends, but in the course of a few years it began to attract the notice of foreign countries, and pupils from every country in Europe flocked to Hofwyl, at once for the sake of studying agriculture, now raised to the dignity of a science, and of imbibing those wholesome moral precepts of which the agricultural system was made the exponent. For 45 years Fellenberg, assisted by his wife, and latterly by his sons, conducted this institution and raised it to the highest point of prosperity and usefulness; and when at length he died, Nov. 21, 1844, he left behind him the reputation of one of his country's greatest benefactors.

FELLOW, in *Colleges*, a distinction which entitles the holder to a share in the revenues of the college. The nature of fellowships is more particularly explained under the head UNIVERSITIES.

FELO-DE-SE, one who commits felony by suicide, or who, being of sane mind and the age of discretion, deliberately takes away his own life. The chattels, real and personal, of a felo-de-se are forfeited to the crown, but not his lands of inheritance; nor is his wife barred of her dower. The forfeited chattels, however, are usually restored upon the payment of certain fees. Formerly, a felo-de-se was buried in the highway, with a stake thrust through his body; but this barbarous usage was abolished by act 4th Geo. IV., cap. 52, which provides that he be privately interred in a burial-ground, between the hours of nine and twelve at night.

FELON, in *Law*, a person guilty of felony.

FELONY, in the general acceptation of the law, comprehends every species of crime which occasions at common law the forfeiture of lands or goods. This most frequently happens in those crimes for which a capital punishment either is or used to be inflicted; for those felonies which are called *clergyable*, or to which the benefit of clergy extends, were anciently punished with death in all lay or unlearned offenders; though now, by the statute law, that punishment is for the first offence universally remitted. Treason itself, says Sir Edward Coke, was anciently included under the name of *felony;* and in confirmation of this we may observe, that the statute of treasons (25 Edw. III. cap. 2), speaking of some dubious crimes, directs a reference to parliament, that it may be there adjudged "whether they be treason or *other* felony." All treasons, therefore, strictly speaking, are felonies; though all felonies are not treason. And to this also we may add, that all offences now capital are in some degree or other felonies; but this is likewise the case with some other offences which are not punished with death, as suicide, where the party is already dead, manslaughter, and larceny; all which are, strictly speaking, felonies, as they subject those who commit them to forfeitures. Upon the whole, therefore, the only adequate definition of felony seems to be that which was before laid down, namely, an offence which occasions a total forfeiture of either lands or goods, or both, at the common law, and to which capital or other punishment may be superadded, according to the degree of guilt.

The word *felony*, or *felonia*, is undoubtedly of feudal origin, being frequently to be met with in the books of feuds, and in other works; but the derivation of it has much puzzled the juridical lexicographers Pratæus, Calvinus, and others. Some derive it from the Greek φηλός, *an impostor* or *deceiver;* others from the Latin *fallo, fefelli*, to countenance which they would have called it *fellonia*. Sir Edward Coke has given a still stranger etymology; that it is *crimen animo felleo perpetratum*, a crime perpetrated with a bitter or gallish inclination. But all agree in the description that it is such a crime as involves the forfeiture of the offender's lands or goods. And this gives great probability to Sir Henry Spelman's derivation from the Teutonic or German, in which language, indeed, as the word is clearly of feudal origin, we ought rather to look for its signification, than amongst the Greeks and Romans. *Felon*, then, according to him, is derived from two northern words, namely, FEE, signifying the fief, feud, or beneficiary estate; and LON, which means price or value. Felony is therefore the same as *pretium feudi*, the consideration for which a man gives up his fief; as we say in common speech, such an act is as much as your life or estate is worth. In this sense it clearly signifies the feudal forfeiture or act by which an estate is forfeited, or escheats to the lord.

To confirm this we may observe, that in the sense of forfeiture to the lord, the feudal writers constantly use it. For all those acts, whether of a criminal nature or not, which at this day are generally forfeitures of copyhold estates, are styled *feloniæ* in the feodal law: *scilicet, per quas feudum amittitur*. Thus, *si domino deservire noluerit; si per annum et diem cessaverit in petenda investitura; si dominum ejuraverit*, id est, *negaverit se a domino feudum habere; si a domino in jus eum vacante, ter citatus non comparuerit;* all which, with many others, are still causes of forfeiture in our copyhold estates, and were denominated *felonies* by the feudal constitutions. So likewise injuries of a more substantial or criminal nature were denominated *felonies*, that is, forfeitures; as assaulting or beating the lord; vitiating his wife or daughter, *si dominum cucurbitaverit*, id est, *cum uxore ejus concubuerit;* all these are esteemed felonies, and the latter is expressly so denominated, *si fecerit feloniam, dominum forte cucurbitando* And as these contempts or smaller offences were felonies or acts of forfeiture, of course greater crimes, as murder and robbery, fell under the same denomination. On the other hand, the lord might be guilty of felony, or forfeit his seignory to the vassal, by the same act as that by which the vassal would have forfeited his feud to the lord. *Si dominus commiserit feloniam, per quam vasallus amitteret feudum si eum commiserit in dominum, feudi proprietatem etiam do-*

minus perdere debet. One instance given of this sort of felony in the lord is beating the servant of his vassal, so that his service is lost; which seems merely in the nature of a civil injury, in as far as it respects the vassal. And all these felonies were to be determined *per laudamentum sive judicium parium suorum*, in the lord's court; as with us forfeitures of copyhold lands are presentable by the homage in the court-baron.

Felony, and the act of forfeiture to the lord, being thus synonymous terms in the feudal law, we may easily trace the reason why, upon the introduction of that law into England, the crimes which induced such forfeiture or escheat of lands (and by a small deflection from the original sense, such as induced the forfeiture of goods also) were denominated *felonies*. Thus it was that suicide, robbery, and rape, were felonies; that is, the consequence of such crimes was forfeiture: but by long use we began to signify by the term *felony* the crime actually committed, and not the penal consequence thereof. And upon this system only can we explain the reason why treason in ancient times was held to be a species of felony; we mean, because it induced a forfeiture.

Hence it follows, that capital punishment does not by any means enter into the true idea and definition of *felony*. Felony may be without inflicting capital punishment, as in the cases instanced of self-murder, manslaughter, and larceny; and it is possible that capital punishments may be inflicted, and yet the offence be no felony, as in the case of heresy, by the common law, which, though capital, never worked any forfeiture of lands or goods—an inseparable incident to felony. And of the same nature was the ancient punishment for standing mute, without pleading to an indictment; which at the common law was capital, but without any forfeiture, so that such standing mute was no felony. In short, the true criterion of felony is forfeiture; for, as Sir Edward Coke observes, in all felonies which are punishable with death, the offender loses his lands in fee-simple, and also his goods and chattels; but in such as are not punishable he loses his goods and chattels only.

There is a discretionary power in justices either to admit to bail, or to commit to prison, as to all felonies (except treason). The compounding of a felony by taking a reward for forbearing to prosecute is punishable with fine and imprisonment, and the mere concealment of a felony is similarly punishable.

FELSPAR. See MINERALOGY, and GEOLOGY.

FELT, a kind of stuff resembling coarse cloth, made of hair or wool, without weaving. The fur of the hare, rabbit, seal, beaver, and the wool of the sheep, are the materials chiefly used for making felt. The hairs and loose flocks of wool are thoroughly mixed together by an operation called *bowing*, which depends on the vibrations of an elastic string; when, in consequence of their anatomical structure, they become matted together. This mass, after undergoing pressure to render it firmer, is dipped into a liquor containing a little sulphuric acid; and, when intended to form a hat, it is first moulded into a large conical figure, which is afterwards reduced in its dimensions by working it with the hands. It is afterwards formed into a flat surface, with several concentric folds, which are still further compacted in order to form the brim and the circular part of the crown. It is then forced on a block, which serves as a mould for the cylindrical part of the hat. The nap or outer portion of the fur is afterwards raised by the application of a fine wire brush. The hat is subsequently dyed and stiffened with glue, or with an aqueous solution of shellac. It need scarcely be observed, that these processes are not applicable to the silk hat now in such very general use. See HAT-MAKING. Besides its use in hat-making, felt is much employed to encase the cylinders of steam-engines, and is also rendered waterproof to be applied in the roofing of houses and many other ways. Attempts have been made to form woollen cloths by a process similar to that of felting, without spinning or weaving; but the cloth made in this way has little strength or durability.

FELTHAM, OWEN, author of the *Resolves, Divine, Moral, and Political*, was a native of Suffolk. Of his private life so little is known that the dates of his birth and death can only be appoximately conjectured. He was born in the reign of James I., and he was alive in 1677. Beyond this nothing has been ascertained concerning him, except that his learning and great moral worth gained for him the favourable opinion of the Earl of Thomond, and that he enjoyed the hospitality of that nobleman for several years. His only work, the *Resolves*, which is a collection of moral essays, divided into centuries, is replete with the most profound thought and brilliant wit exercised on subjects chiefly moral and religious, and displays at the same time so true and great a knowledge of the world that readers of every class cannot fail to be interested and instructed by a perusal of its pages. It has been very frequently reprinted.

FELUCCA (Ital. *feluca*), a little vessel with oars and lateen sails, common in the Mediterranean. It has a rudder at the stem and another at the stern, to be applied as occasion requires.

FELTRE, the ancient *Feltria*, a town of Northern Italy, delegation of Belluno, and 16 miles S.W. of the town of that name. It stands on a hill at the foot of the Alps, near the Piave, and has about 5500 inhabitants. The town is partially fortified, and contains a handsome market-place, cathedral, numerous churches, an episcopal gymnasium, diocesan school, orphan asylum, &c. It has some trade in corn, wine, and oil, and manufactures of silk twist, wax, and leather.

FEMERN, an island in the Baltic, belonging to Denmark, and lying off the coast of Holstein, from which it is separated by the Femer-sund, a channel about a mile wide. Area, 70 square miles. Pop. (1846) 8860. The surface is low and level, producing corn, and affording good pasturage for cattle, but the people devote their attention principally to fishing. The chief town of the island is Burg, containing about 1800 inhabitants.

FEMME COVERT, in *Law*, a married woman: as *femme sole* signifies an unmarried woman.

FEMININE, in *Grammar*. See GENDER, and GRAMMAR.

FEN, low land occasionally overflowed with water, or abounding with pools or lakes, with intervening spots of dry land. See AGRICULTURE, vol. ii., p. 362, &c.; BEDFORD LEVEL; LINCOLNSHIRE; and M'Culloch's *Statistical Account of Britain*, vol. i., p. 24.

FENCES. See AGRICULTURE, vol. ii., p. 269; GARDENING; HORTICULTURE; FOREST; and M'Culloch's *Statistical Account*, vol. i., p. 467.

FENCE-MONTH, the month in which deer begin to fawn, when hunting in the forest is prohibited. It commences fifteen days before Midsummer, and ends fifteen days after it.

FENCING, is the proper use of the small-sword or foil. The small-sword is a light court-dress sword, made to taper gradually from the hilt to the point, and of a size regulated by the judgment of the wearer, if he understand the use of the weapon. The foil, with which the art of fencing is practised, is a small quadrangular blade, about the length of a small sword, and mounted in nearly the same manner; but, for the convenience of the exercise, it is made lighter, blunted, and covered with leather at the point, to prevent accidents in practice.

The first weapon in use among mankind, whether for offensive or defensive purposes, appears to have been the sword, and combat with this weapon is perhaps nearly as old as the world. The most ancient book extant makes frequent mention of the sword, and the same thing may be

said of Homer, who is full of continual allusions to this weapon. The earliest swords were probably made of wood, like those used by the natives of Mexico when first visited by the Spaniards; but after the discovery of metals, bronze swords were introduced, of which kind many have at different times been found in Ireland. As soon, however, as the art of tempering steel had been discovered, that metal superseded all other substances in the fabrication of arms; nor is it probable that any change in this respect will take place, or that any further improvement is attainable. The form of the sword, however, has varied at different times and in different countries. Those used by the Roman legions were short and strong, with a blade seldom exceeding nineteen inches in length, but two-edged, and calculated both for the cut and the thrust. The British swords, called *spathæ*, were large, long, and heavy; and the Saxon and the Norman partook of the same character. The ancient practice of the weapon was probably carried to its greatest perfection amongst the Romans, whose partiality for gladiatorial exhibitions formed a remarkable feature of their character. The various and complicated methods of combat in which this celebrated people took delight are either alluded to or described by most of their writers, particularly by Livy, Juvenal, Seneca, and Suetonius.

The history of the modern small-sword or rapier is involved in some obscurity. The latter term, though now considered as synonymous with the former, properly denotes a long, ordinary, old-fashioned, cutting sword. But modern usage has identified the expressions, and by a rapier is now always meant a sword for the thrust, in contradistinction to one constructed for cutting. The small-sword or rapier is undoubtedly very ancient, although there is reason to believe that it was not brought into general use until armour began to wear out of fashion. Since that time the art of fencing has always been considered as a gentlemanly accomplishment, and in many parts of the Continent it is cultivated with the greatest zeal and assiduity. Shakspeare, indeed, makes Hamlet, who lived at the court of Florwendillus, a fencer; but as our great dramatist has not been very careful in avoiding anachronisms, it may reasonably be doubted whether the small-sword has any claim to such antiquity. Some have maintained that the weapon was not used in England before the reign of Elizabeth; and Darcie (*Annals of Elizabeth*) informs us that one Rowland York, who appears to have betrayed Deventer to the Spaniards in the year 1587, was the first who brought into England "that wicked, pernicious fashion to fight in the fields in duels with a rapier called a tucke only for the thrust." Stowe also mentions that long tucks and long rapiers began about the twelfth or thirteenth year of Elizabeth, and that "he was held the greatest gallant that had the deepest ruffe and largest rapier. The offence," he adds, "to the eye of the one, and the hurt unto the life of the subject that came by the other, caused her majesty to make proclamation against them both, and to place selected grave citizens at every gate to cut the ruffes and breake the rapier's points of all passengers that exceeded a yard in length of their rapiers, and a nayle of a yard in depth of their ruffes."[1]

But at what time soever the small-sword came into use in this country, it is not surprising that, when once introduced, it should have been cultivated as the fairest and most equitable instrument of duelling. Before this period meetings for the purpose of single combat were utterly revolting to human nature. No regard was paid to equality of arms or numbers; advantages, however unfair, were seized whenever an opportunity offered; and the ferocious passions, instead of being curbed, had fuller scope given for their gratification. "The duellist of former times," says Sir Walter Scott, in a note to *The Lady of the Lake*, "did not always stand upon those punctilios respecting equality of arms, which are now judged essential to fair combat. It is true that in formal combats in the lists, parties were, by the judges of the field, put as nearly as possible in the same circumstances. But in private duels it was often otherwise." In the desperate combat which was fought between Quelus, a minion of Henry III. of France, and Antraquet, with two seconds on each side, and from which only two persons escaped alive, Quelus complained that his antagonist had the advantage of a poniard which he used in parrying, whilst his own left hand, which he was obliged to use for the same purpose, had been cruelly mangled. When he charged Antraquet with this odds, "Thou hast done wrong," answered the latter, "to forget thy dagger at home; we are here to fight, not to settle punctilios of arms." In another duel of a similar kind, however, a younger brother of the house of Aubange in Angoulême behaved more generously, and at once threw away his dagger when his antagonist challenged it as an undue advantage. Nevertheless, it would be difficult to conceive any thing more brutal and savage than the mode in which private quarrels were at this time conducted in France. Those who were most jealous on the point of honour, and who thence acquired the title of *raffinés*, did not scruple to avail themselves of every advantage of strength, numbers, surprise, and arms, in order to accomplish their revenge. See DUEL.

Brantôme, in his discourse on duels, informs us that the Italian masters of the science of defence made a great mystery of their art and mode of instruction; that they never suffered any person to be present except the scholar who was to be taught, and even examined beds, closets, and other places of probable concealment. The lessons of these teachers often gave the most treacherous advantages to their pupils; for the challenger having by usage a right to choose his weapons, frequently selected some strange and inconvenient kind of arms, the use of which he had practised under his instructor, and thus killed at his ease an antagonist, to whom, perchance, the weapon was presented for the first time on the field of battle. Nor can we doubt that the same, or even still more treacherous advantages, are taught by some Italian masters of the present day, especially when we learn, from an authentic publication of the life of a late pope, that in Rome upwards of a thousand persons annually fall victims to the stiletto, either by the hands of hired assassins, or in private quarrels. Dr Moore estimates the number of murders perpetrated by the dagger in Naples alone at not less than four hundred annually. Such are the cowardly and ferocious modes in which vengeance usually seeks its gratification amidst an enslaved and degraded people.

The practice of deciding duels with the sword, however, may be considered as now extinct in this country. When the rapier was looked upon as an indispensable part of a gentleman's dress, the facility of immediate rencounter which it offered gave occasion to frequent and dangerous brawls, by which the public tranquillity was disturbed, and the lives of peaceable citizens sometimes sacrificed. But still it may reasonably be doubted, whether the comparatively rare occurrence of duels since the introduction of the pis-

[1] In *The Two Angry Women of Abingdon*, a comedy printed in 1599, we find the following pathetic complaint: "Sword and buckler fights begin to grow out of use. I am sorry for it; I shall never see good manhood again. If it be once gone, this poking fight of rapier and dagger will come up; then a tall man, and a good sword-and-buckler man, will be spitted like a cat or a rabbit."

tol, has not been overbalanced by a long list of fatal results, not to mention amputated limbs and distressing mutilations. Be this as it may, however, the discontinuance of sword duels in England has, in a great measure, removed one of the chief objections against fencing; namely, that adroitness in the use of weapons creates a fondness for contention, and a disposition to indulge in violence and insult. Since arms have ceased to be worn, such an objection can no longer be urged against the art of defence; and it may perhaps be questioned whether it had much weight, even when arms formed part of the equipment of every one who called himself a gentleman. All parties were thus placed upon nearly an equal footing; and if turbulent characters went about armed, there was nothing to prevent the peaceably disposed from being as well provided as the brawlers, and also on a par with them in respect of skill in the use of weapons. If the thief makes use of a crowbar, the honest housekeeper has the protection of an iron bolt. The primary intention of fencing is the security of one's own person; and where the weapons and the art of using them skilfully were equally accessible to all, the evil disposed had no advantage, and therefore small temptation to indulge their turbulent propensities.

The practice of the foil in England, however, is now confined to the most laudable purposes, namely, the enjoyment of salutary recreation, and the acquisition of a graceful and unconstrained deportment. The beneficial effects of moderate fencing to persons of weak constitutions, or of studious and sedentary habits, have been attested by medical practitioners of the first eminence. On this subject the suffrages of the most distinguished members of the British schools of medicine and of surgery, which Mr Angelo has annexed to his engravings, illustrative of the fencing attitudes, seem completely decisive.[1] To the public speaker, also, the practice of the fencing-room has been found to impart an ease and freedom of gesture attainable perhaps by no other exercise, not excepting even the discipline of the ballet-master. A modern writer on the subject of delivery or elocution, gives it as his opinion that the use of the foil and the broadsword diffuses ease, elegance, and grace all over the body, and imparts to the look and gesture an appearance of intellectual vigour. It does more; it teaches invaluable lessons of patience and self-command, and contributes to discipline the temper, whilst it serves to develope the corporeal powers, and to strengthen them by unconstrained and salutary exercise. We may add here, that several works of merit have appeared on this subject; but the most valuable and complete one yet published is Roland's *Treatise on the Theory and Practice of the Art of Fencing*, Edinburgh, 1823; nearly all the others we have met with being deficient either in explanation or in practical utility.

Having already described the weapons used in fencing, we shall now proceed to give such definitions as appear to be requisite for conveying a general idea of the subject, referring the reader for the necessary details to the excellent work of Mr Roland, which will be found equally clear in its explanations, and comprehensive in its views of every branch of the art.

After the first positions have been acquired, the different modes of attack come to be considered. *Attacks* are made in three ways: first, by a quick thrust proceeding merely from the wrist, the arm at the same time being elevated and advanced, with the point directed towards the adversary's breast; secondly, by what is technically called an extension; and, lastly, by longeing and recovering. The *parades*, in which consists the defensive part of the art, naturally follow the attack. A parade is a defence of the body, made by an opposition of one's blade to that of an adversary, in such a situation as, upon his attack, to prevent the point of his sword hitting. The parades are eight in number, viz. six simple, and two round or counter parades, and they are called *quarte, tierce, circle, octave, prime, quinte*, and round or counter in quarte and tierce. When and how these parades are made in fencing may be learned by consulting Mr Roland's work (p. 32 et seqq.).

The next division of the subject includes *straight thrusts, simple disengagements*, and *bindings of the blade*. A *straight thrust* is used as an attack, when an antagonist, from his position on guard, leaves sufficient opening to enable him to be touched upon that side of the body on which blades are joined. When such an opportunity offers, the wrist must be suddenly raised, so as to bring the *forte* of one's sword to the *foible* of the adversary's; after which *longe* immediately on the same line to his breast, observing, however, to preserve a correct opposition. In fencing, *opposition* signifies the art of covering the body at the time of delivering a thrust, on that side where the foils happen to cross, in order to prevent an antagonist exchanging hits. The *disengagement* is made either as an attack, or as a return after defending one's-self from a thrust, and is executed both under and over the wrist or foils. A disengagement over the arm may be parried with tierce or prime, and, if made low, by the parade of circle; from the position of octave, by quarte, or, if the thrust be delivered low, by circle; from the position of quinte, by prime as the readiest defence, but quarte and tierce are also correct parades against this thrust. There are three different ways of *binding the blade*. Of these, *flanconnade* is the principal, as it is sometimes a safe attack when any other mode would be attended with considerable danger; it is also made as a *riposte*. The attack of flanconnade is commenced when the blades are joined in quarte, and it is parried either by octave or quinte, or by the parade of quarte. The return over the arm, after the parade of circle, is parried by prime or tierce, or by changing quickly to the counter in quarte. The return over the arm, after the parade of prime, is parried by prime or tierce, or, if made at a considerable distance, by the counter in quarte.

In fencing there are a great variety of *feints*, which it is not easy to describe intelligibly without figures. A *feint* is an intentional movement made to deceive an adversary. All thrusts, therefore, may, strictly speaking, come under the definition of feints, as the fencer's object, in all his attacks, is to deceive his antagonist. For the sake of convenience, however, straight thrusts and simple disengagements have been arranged under a separate head. In executing the feint called *one, two*, inside of the arm, supposing the adversary's body to be covered in quarte, the parade of tierce is deceived; commencing from the outside, that of quarte is deceived; from the position of the circle the octave, and from that of the octave the circle is deceived.

[1] "Perhaps there is no exercise whatever," says Mr Roland, "more calculated for these purposes (developing and cultivating bodily strength and activity) than fencing. Riding, walking, sparring, wrestling, running, and pitching the bar, are all of them certainly highly beneficial; but, beyond all question, there is no single exercise which combines so many advantages as fencing. By it the muscles of every part of the body are brought into play; it expands the chest, and occasions an equal distribution of the blood, and other circulating fluids, through the whole system. More than one case has fallen under the author's own observation, in which affections of the lungs, and a tendency to consumption, have been entirely removed by occasional practice with the foil; and he can state, upon very high medical authority, that since the institution of a *Salle d'Armes* at Geneva, scrofula, which was long lamentably prevalent there, has been gradually disappearing." (*Theory and Practice of Fencing*, p. 163.)

This feint, if made inside the arm, is parried by the parade of quarte, or by the counter in tierce, made upon an opponent's second disengagement; upon the outside of the arm, by tierce, prime, or the counter in quarte; and from the position of the octave, by octave or quinte. The feint *one, two*, is likewise made as a return after the parade of quarte or tierce, or sometimes after that of circle or octave. The *cut and disengage* is a species of *one, two*, in making which from the position of quarte, an adversary's parade of tierce is deceived, and from the position of tierce his parade of quarte. *Cut and disengage*, if made inside of the arm, is parried by quarte, or the counter in tierce; if outside, by tierce or counter in quarte. *Feint seconde* is another feint very nearly resembling *one, two*, and is generally made as a return after the parades of tierce, prime, or quinte. In this feint the octave or quinte is deceived; and it is parried by tierce, prime, or quarte, the two former being the readiest where quinte is the parade deceived, but if the feint has been answered with octave, the thrust must then be parried with quarte. The feint *one, two, three*, is made on either side of the blade, upon precisely the same principles as *one, two;* the only difference between them consisting in making one disengagement more in the latter than in the former movement. The *cut and one two* is a species of *one, two, three*. These feints, if made over the arm, are parried with the simple parade of tierce; if on the inside, with simple quarte. The other feints are, *doubling*, which, *mutatis mutandis*, is executed upon precisely the same principles; *one two and deceive the circle*, executed from the inside position of quarte; *one two and deceive the counter*, which may be made from either side of the blade, but is most frequently used commencing from the position of tierce; *feint flanconnade*, which can be commenced only from the engagement of quarte; *feint one two and deceive octave*, which is commenced either from the outside or inside engagement; *feint seconde and deceive quarte*, which is always commenced from the outside engagement, whether made as an attack or a return; *feint seconde and deceive tierce*, which differs from the preceding only in the last disengagement; *one two and deceive quarte from the position of the circle*, when the first disengagement is made over the adversary's wrist towards the body under the arm, and the second over the wrist towards the inside of the body; and *doubling on both sides of the arm*, which is too complicated a feint to be frequently used in actual fencing, because it is difficult to follow the adversary's sword with certainty through many different parades, and there is much danger of *time thrusts* upon feints which consist of so many disengagements.

Time thrusts are so called because the success of these movements depends entirely upon their being executed at the exact moment of time employed by the adversary in planning or in executing his attack; and, when made correctly, they are by far the most scientific movements in fencing. There are two sorts of time thrusts, in the execution of one of which it is necessary that the blades should cross each other, but for the completion of the other it is not absolutely necessary that the blades should even meet. Those time thrusts in the execution of which the blades cross are more scientific, and expose the fencer less to exchanged hits. There are two time thrusts *in opposition;* one the *time over the arm*, and the other the *time in octave*. The former is applicable to all thrusts, however simple or complex the feint may be, provided the longe is made upon the outside; whereas all longes directed to the inside of the body, or under the arm, are exposed to the time in octave; and thus almost every thrust made in fencing affords an opportunity for one or other of these two movements. Those time thrusts in which the opposition is not essential are made upon incorrect movements of the adversary, when he exposes himself by the wideness of his attacks, or by quitting the blade in a dangerous position, or by making too many disengagements in his feints, or by giving a variety of openings which the judgment of the fencer must determine how he is to take advantage of. This thrust is practised almost entirely upon irregular attacks, and requires great caution to be observed. It has been already stated, that time thrusts in opposition, when correctly made upon good attacks, are, perhaps, the finest movements in fencing; but young fencers should nevertheless attempt them very seldom, from the danger of misjudging the attack, and thus exposing themselves to the certainty of being hit. And the time out of opposition is attended with still greater hazard, as its success depends rather upon the wideness and irregularity of an adversary's movements, than on the security of one's own situation afforded by the opposition in the former species of time thrust.

When fencing was comparatively little known, it was thought necessary that there should be some intermediate practice for the pupil between the lesson of the master and his making the assault; for which purpose, it appears, he was taught to longe, at a proper distance, at the wall. This was called by the French *tirer au mur*, and was considered as useful for planting the learner well upon his legs, accustoming him to measure distance correctly, and causing his motions, in making his extension and longe, to follow one another in the proper succession. But as the art became better understood, observation induced masters to place pupils together for their mutual advantage, the one to attack by simple disengagements, the other to parry by quarte and tierce alternately; and this practice, from its origin, was for a considerable time called *tirer au mur*, a denomination which it still retains amongst fencers of the old school. It is now, however, generally known by the denomination of *quarte and tierce*, and, in its improved state, is not merely intended as an exercise for the scholar, but also as a graceful display of the principal motions of fencing; for which reason it should be invariably practised before commencing the assault, and in fencing before company it is never dispensed with. Quarte and tierce appears very simple in its execution, yet it is exceedingly useful to fencers in all stages of their progress, and difficult to acquire with such correctness that all its movements shall take place in their proper succession, and be made with the grace and precision characteristic of a good fencer. For a description of the method of thrusting quarte and tierce, we must refer the reader to the fifth chapter of Mr Roland's work, section first. The *counters* is also a practice of importance to young fencers, and should consequently be attended to by them.

In the language of the fencing-room, making the *assault* and *playing loose* are synonymous, signifying the practice of attack and defence, or, in other words, a just application of the lessons received, which, in fact, ought to be done as correctly as if with sword in hand. In the assault, the mere movements should be almost mechanical; for the mind being wholly employed in discovering and counteracting the designs of the adversary, as well as in concealing its own, the hand should, on the proper opportunity being given, instantly execute that which the mind conceives, without any consideration of the manner in which the particular motion is to be made, as loss of time would most probably prove fatal to its success. The rules to be observed are few and distinct. The first thing which the attention of a young fencer should naturally be directed to is, the most secure manner in which he can come into the position of the guard, when opposed to an adversary ready to take every advantage of his inexperience. Whilst advancing into distance, it is also an object of importance to have one side of the body secured by the position, particularly that side to which the antagonist's blade is opposed; so that, if he commence an attack during this movement, he must quit the blade in or-

der to direct his thrust or feint at any opening afforded him by the position of his opponent; and the opportunities of attack being few, his designs will thus be the more easily discovered. In short, the commanding an opponent's blade almost obliges him to effect some change in the relative situations of the contending parties, before he advances into distance; and as the necessity of such previous movement must be foreseen, any attempt of this kind is favourable for making an attack on him. And, generally, whilst standing in the position of the guard, it is an advantage to have one side of the body covered, and to command the foible of the adversary's blade. Straight thrusts and simple disengagements, executed with quickness and vigour, should frequently be attempted, even though they do not succeed in hitting; and this counsel should be particularly attended to in fencing with a stranger. Quick simple thrusts are almost the only certain way of ascertaining his favourite parades, and consequently of knowing by what feints to attack him with a probability of success. The suddenness and rapidity of the attack will inevitably extort from him the secret of his favourite defence.

Many masters of the old school, and some, too, of the present day, have treated *disarming* as a matter of importance in the art; but, from its inutility, not to mention danger, in the field, it is now considered by the highest authorities on the subject as incompatible with good fencing. Mr Roland, in the work already referred to, shows by what methods this may be accomplished, and at the same time demonstrates the utter uselessness of the trick, for it is no better. The only advantage of disarming indeed is that of annoying the person disarmed; for, sword in hand, it is rendered nugatory by the use of a sword-knot, with which, it may be presumed, every person at all acquainted with the weapon will take especial care to fasten it to his wrist in a serious affair. As the manœuvre of disarming may therefore be defeated by the most ordinary precaution, attempting it can serve no other purpose than to make one play heavily and unpleasantly; whilst, from the strength it requires for the execution of its movements, it takes from the necessary quickness, and affords an adversary favourable moments of attack during the time an attempt is being made to bind his blade. In short, disarming is considered as characteristic of unskilful fencing; since perfection in the trick can only tend to render fencing disagreeable with the foil and ineffectual with the sword. We may add, that *volting, demi-volting, pirouetting*, parrying with and opposing the left hand, are manœuvres now totally disused in fencing.

As far back as 1692 a very curious book on the subject of fencing was published by Sir William Hope; it is now very scarce. In 1780 a Lieutenant M'Arthur published a work on fencing, which he dedicated to the Duke of Argyll, and which, we believe, is considered as a respectable performance. But since the latter period nothing worth noticing appears to have been written on the subject, with the exception of Angelo's book, illustrated by engravings, and the works of the two Rolands; of these, the most complete and satisfactory is Mr George Roland's *Treatise on the Theory and Practice of Fencing* above referred to. The only standard French works on the subject are, a Treatise by M. Danet, director of the royal academy of privileged fencing-masters; and one by M. Laboissier; both works of great merit, and highly esteemed. (J. B—E.)

FENELON, François de Salignac de Lamotte, was descended of an ancient and illustrious family, and born at the castle of Fénélon in Périgord, on the 6th of August 1651. Under the eyes of a virtuous father, he advanced in his literary studies with equal rapidity and success; and being from childhood nurtured in classical antiquity, and in particular familiarised in his solitude with the masterpieces of Grecian genius, his taste was formed on the purest models, whilst his benign genius was simultaneously developed. Called to Paris by his uncle, the Marquis of Fénélon, to complete his philosophical studies, and commence the course of theology requisite for the vocation to which he was destined, he, at the age of fifteen, underwent the same trial as Bossuet, and preached before an auditory, less distinguished, perhaps, than that which assembled in the hôtel de Rambouillet, but still highly respectable, who listened to him with a mixture of surprise and admiration. But this premature reputation rather alarmed than gratified the Marquis of Fénélon, who, in order to withdraw the young apostle from the seductions of the world and of glory, placed him in the seminary of St Sulpice. In this retreat Fénélon imbibed the evangelical spirit, and acquired the friendship of the virtuous Tronson, the superior of the establishment; and here also he received holy orders. About this time his religious fervour inspired him with the design of devoting himself to the missions in Canada. But being thwarted in this scheme by the apprehensions of his family and the weakness of his constitution, he soon turned his regards towards the missions of the Levant, particularly Greece, where the sacred and the profane, St Paul and Socrates, the church of Corinth, the Parthenon, and Parnassus, equally invited his poetical and religious imagination. Fortunately for the Catholic church and for France, however, this project also misgave; and Fénélon, diverted from distant missions, devoted himself to an apostleship, which he thought not less useful, namely, the instruction of the *Nouvelles Catholiques*, or newly-converted women in Paris. The duties and cares of this employment, in which he buried his genius during ten years, prepared him for the composition of his first work, entitled *Traité de l'Education des Filles*, a masterpiece of delicacy and of reason, which has not been equalled by the author of *Emile* and painter of Sophie. This work was intended for the Duchess of Beauvilliers, the pious mother of a numerous family. In the modest obscurity of his ministry, Fénélon had already formed with the Dukes of Beauvilliers and of Chevreuse that virtuous friendship which resisted equally the seductions of favour and the frowns of disgrace, the smiles of the court and the decree of exile. But in the case of Bossuet he met with an attachment which was destined to be much less durable. Admitted into familiarity with this great man, Fénélon studied his genius and his life; and the example of Bossuet, whose polemical religion exercised itself in controversies and conversions, probably suggested to him the *Traité du Ministère des Pasteurs*, a work in which he combats the heretics with a moderation which formed no part of the character of his illustrious model. The subject, the merit of this work, and the all-powerful suffrage of Bossuet in its favour, induced Louis XIV. to confide to Fénélon the charge of a new mission to Poitou. The rigorous uniformity which the French monarch was desirous of establishing in matters of religion, and the resistance which sprung from the oppressive measures adopted for this purpose, often obliged the monarch to cause his missionaries be supported by troops. Fénélon, however, not only rejected peremptorily the co-operation of the dragoons, but even reserved to himself the choice of the ecclesiastical colleagues who should share with him in the ministry of persuasion and gentleness. He converted without persecuting, and made the faith of which he was the apostle an object of love instead of hatred. The importance which was then attached to such missions fixed all eyes upon Fénélon, who had so happily acquitted himself of that entrusted to his care.

A great object was now presented to his ambition and his talents. The dauphin, grandson of Louis XIV., had

at length passed the period of childhood, and the king was looking out for a person to whom the education of the young prince might be confided. This was in the year 1689. By the favour of Madame de Maintenon, virtue obtained the preference in this appointment. M. de Beauvilliers was named governor, and he recommended to the king Fénélon as preceptor of the young prince. These virtuous friends, seconded by the attentions of men worthy of imitating them, commenced the task of educating the future king; and history attests that there was never seen a more perfect concurrence of principle and exertion. But Fénélon, by the natural superiority of his genius, formed the soul of this reunion; it was he who, transported by the hope of one day realizing the *beau ideal* of a prince on the throne, and viewing the happiness of France as in a great measure dependent on the education of its future sovereign, destroyed with admirable art all the dangerous germs which nature and the premature sentiment of power had implanted in his youthful breast, and gradually moulded an almost indomitable character to the habit of the most salutary virtues. This system of education, precious vestiges of which remain in some of the writings of Fénélon, appears to have been a masterpiece of that genius which devotes itself to advance the happiness of mankind. When brought into the midst of the court, Fénélon, without intermingling in its intrigues, secured general admiration by the graces of his brilliant and ready wit, and the charm of his noble and eloquent conversation. In his character the apostle and the great lord seemed to be strangely united. Imagination and genius escaped him on all occasions; and the most refined politeness at once embellished and rendered pardonable in the eyes of courtiers, the ascendency of his talents. This personal superiority indeed excited much more admiration than even the writings which proceeded from his pen, and, at the period of his reception in the Academy, was made the subject of eloquent commendation. "On sent," says La Bruyère, writing of him soon afterwards, "la force et l'ascendant de ce rare esprit, soit qu'il prêche de génie et sans préparation, soit qu'il prononce un discours étudié et oratoire, soit qu'il explique ses pensées dans la conversation; toujours maître de l'oreille et du cœur de ceux qui l'écoutent, il ne leur permet pas d'envier ni tant d'élévation, ni tant de faculté de delicatesse de politesse." This ascendency of virtue, of grace, and of genius, which excited in the hearts of the friends of Fénélon a tenderness mixed with enthusiasm, and which had even won Madame de Maintenon, in spite of her distrust and reserve, proved altogether unavailing against the prepossessions of Louis XIV. This monarch no doubt esteemed the man to whom he had confided the education of his grandson, but he never had any relish for his society. It is supposed indeed that the brilliant and ready elocution of Fénélon was distasteful to Louis, intolerant as he was of any sort of pre-eminence except his own. But if we cast our eyes on the letter in which Fénélon, in an expansion of confidence, informed Madame de Maintenon "that Louis XIV. had no idea of his duties as a king," we shall probably find, in the expression of this honest but uncourtly opinion, a better explanation of the aversion of a monarch accustomed to adulation, than in any supposed jealousy of the superiority of his conversational powers. Fénélon passed five years in the eminent situation of preceptor to the dauphin, without asking or receiving any thing; and, indeed, during his residence at court he had preserved the most irreproachable disinterestedness. Louis XIV. however, who knew how to recompense merit, even though its possessor might not be personally agreeable to himself, wished to repair this oversight, and, in 1694, named Fénélon Archbishop of Cambrai.

But at this moment of favour and prosperity his credit was destined to receive a blow, which would have inflicted a mortal wound on a less inviolable reputation. Fénélon, whose natural temperament disposed him to cherish a lively and spiritual devotion, had for some time fancied that he recognised some of his own principles in the mouth of a pious enthusiast, who, no doubt, had great talents for persuasion, since she obtained an extraordinary influence over several superior minds. Madame Guyon, writing and discoursing on grace and on pure love, at first persecuted and arrested, soon afterwards admitted into the intimate society of the Duke of Beauvilliers, received by Madame de Maintenon, and authorized to disseminate her doctrine in St Cyr, then suspected by Bossuet, arrested anew, interrogated, and condemned, served as a pretext for the disgrace of Fénélon. The inexorable Bossuet, who loved not the mystical subtilties and refinements concerning divine love, with which the lively and tender imagination of Fénélon was captivated, wished to bring it about that the new Archbishop of Cambrai should himself condemn the errors of a woman who had been his friend. Fénélon, however, refused, both from conscience and delicacy, to gratify his antagonist in this particular. Fearing to compromise opinions which were dear to him, wishing to exculpate the pietism of Madame Guyon, whose only offence appeared to consist in some venial exaggeration about the love of God, and perhaps also shocked at the theological haughtiness of Bossuet, who pressed upon him as if for the purpose of proselytism, he stood upon the defensive, and published his *Maximes des Saintes*, which may be regarded as an indirect apology for, or even as a subdued exposition of, the principles of Madame Guyon. In an age when a religious opinion was a political event, the first appearance of this work excited murmurs of astonishment; and all those who had been secretly envious of the genius and the promotion of Fénélon, declared loudly against the errors of his theology. Bossuet, a man incapable of indulging mean or unworthy sentiments, but at the same time inflexible, impatient of contradiction, and regardless of all external observances, when he believed the faith to be compromised, denounced to Louis XIV. in the midst of his court, the alleged heresy of the Archbishop of Cambrai; and at the moment when this attack was made upon Fénélon, the burning of his palace at Cambrai, and the consequent loss of his library, manuscripts, and papers, put his patience to a new trial, yet only drew from him the touching remark, "It is better that the fire should have consumed my dwelling than the cottage of a poor labourer." Nevertheless Bossuet, committed by his declaration to the king, prepared to pursue his rival, and seemed eager to extort from him a recantation; whilst, on the other hand, Madame de Maintenon, hitherto the friend and protectress of Fénélon, treated him with the greatest coldness. In the mean time Fénélon submitted his book to the judgment of the holy see. Bossuet, however, having already composed remarks, in which bitter and vehement censure is surrounded with ostentatious expressions of friendship and regret, proposed a conference; but this Fénélon declined, preferring to defend his book at the tribunal to which he had appealed. It was then that he received orders to quit the court and retire into his diocese; a circumstance which occasioned great grief to the Duke of Burgundy. The cabal wished to profit by the fall of Fénélon to overthrow the Duke of Beauvilliers; but the latter was saved by his own virtuous conduct; for his devotion to the cause his unfortunate friend interested the generosity of Louis XIV. and their design miscarried. Notwithstanding the evident desire of this monarch, however, the court of Rome hesitated to condemn an archbishop so illustrious as Fénélon. But the repugnance evinced by Innocent VIII. only served to stimulate the talents of the accuser and accused; and, whilst

the judges (a commission consisting of ten cardinals) remained undecided, the writings of the two adversaries succeeded one another with prodigious rapidity. The contest had, in fact, now changed its character. After having exhausted the dogma, Bossuet threw himself upon the facts; and the *Relation du Quiétisme*, written with equal spirit and malignity, seemed calculated to involve Fénélon in a portion of the ridicule which inseparably attached to Madame Guyon. The Abbé Bossuet, an unworthy nephew of the Bishop of Meaux, extended still further these personal inculpations, and, having collected some odious rumours, sought to impeach the purity of Fénélon's character. Never did the indignation of a virtuous and calumniated spirit display itself in greater eloquence. Fénélon, in his defence, demolished these vile accusations; and it required new letters from Louis XIV. prepared by Bossuet, and new intrigues, carried even to the extent of menace, to extort from the court of Rome a reluctant condemnation, which, when obtained, was found to be softened both in the form and in the expressions.[1] But the long and glorious resistance of the Archbishop of Cambrai had exasperated to the utmost the resentment of Louis XIV.; and the hesitation of the court of Rome to condemn him rendered his disgrace at that of France more irrecoverable than ever. When the brief, so long delayed, and obtained after so much discussion and intrigue, at length arrived in 1699, Fénélon hastened to subscribe it, and to ratify his own condemnation by a mandatory letter, conceived in the most touching and simple language, although Bossuet did not fail to discover in it much parade and ambiguity.[2]

The modest submission of Fénélon, his silence, his episcopal virtues, and the admiration which these had inspired, would not, in all probability, have re-opened to him the doors of the court of Louis XIV.; but an unexpected event, which occurred at this time, served to irritate that monarch more than ever against him. The *Télémaque*, composed several years previously during the period of his favour, was published some months after the affair about Quietism, through the infidelity of a domestic who had been employed to transcribe the manuscript, and who, it appears, had contrived to take a copy for himself. The work, though suppressed in France, was reproduced by the presses of Holland, and obtained throughout all Europe a success which malignity rendered injurious to Louis XIV., by seeking in it allusions to the conquests and misfortunes of his reign. This prince, who had always disliked the political notions of Fénélon, and had even described him as "un bel esprit chimérique," regarded the author of *Télémaque* as a detractor of his glory, who to the guilt of ingratitude added the more irritating injustice of satire. There cannot be a greater absurdity, however, than to construe this production as a political satire, or to seek in it for allegorical and premeditated censure of Louis XIV.; all the details being, in fact, combined in the best manner imaginable for disconcerting allusions, and avoiding as much as possible the inevitable fatality of resemblances. We are convinced indeed that this generous precaution occupied the mind of Fénélon whilst composing the work, and that, writing for the happiness of nations, he selected those primitive manners, and antique forms of society, which are the most remote from the picture of life presented by modern Europe, but which served equally well to embody his poetical conception, and to suggest those instructive lessons which it was his grand object to inculcate. Besides, why should he have thought of representing Louis XIV. under the character of the imprudent Idomeneus, or that of the sacrilegious Adrastus, rather than under the masterly delineation of the great and virtuous Sesostris?

Fénélon, however, soon learned the indelible impression which *Télémaque* had produced upon the heart of the king; and, resigned to his banishment from court, which he had sometimes the weakness to call his disgrace, he sought to console himself for the loss of the royal favour by endeavouring to diffuse happiness around him in his retreat at Cambrai. The sanctity of the ancient bishops, the severity of the primitive church, the attraction of the most indulgent virtue, the charm of the most captivating politeness, the utmost eagerness to fulfil even the humblest duties of the ministry, indefatigable goodness, inexhaustible charity; such are the traits of Fénélon's character as delineated by an eloquent and virtuous prelate, who knew him well, and who dwells with enthusiasm on the picture which he has drawn of his illustrious friend. The first care of Fénélon was to instruct the clergy of a seminary which he had founded; nor did he even disdain to teach their catechism to the children of his diocese. Like the bishops of ancient days, he often ascended the pulpit of his cathedral, and, trusting at once to his faith and his feelings, spoke without preparation, diffusing all the treasures of his natural eloquence. When the misfortunes of the war, which chastised the ambition of Louis XIV., brought the allied army into the diocese of Cambrai, the occasion called for new efforts and new sacrifices upon the part of the good archbishop, who, by his wisdom, his firmness, and the nobleness of his language, inspired the hostile commanders with a salutary respect for the unfortunate provinces of Flanders. Marlborough and Eugène indeed were worthy of listening to the voice of the great man whose genius and worth they so well appreciated.[3]

The situation of Cambrai on the frontiers of France attracted to the archiepiscopal residence many strangers, none of whom approached or quitted its lord without being affected with a sort of religious admiration. Not to mention Ramsay, who passed several years under his roof, the celebrated Marshal Munich, and the unfortunate Chevalier de St George, called James III., experienced the delight of his society, and derived instruction from his superior sagacity. By the wise counsels which he gave to James III., Fénélon showed his high esteem for the English constitution, powerful alike against despotism on the one hand, and anarchy on the other. The archbishop was exempt from that narrow patriotism which undervalues whatever exists beyond the frontiers. His virtuous and benevolent spirit

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[1] The interest of this discussion, so foreign to the ideas of our age, has been admirably preserved in the excellent *History of Fénélon* by M. de Bausset, in which will be found an animated picture of the court of Rome and of the court of France, which took such a lively interest in this frivolous question, which, however, was aggrandized by the opinions of the time, and the prodigious talents of the rival disputants.

[2] Pope Innocent, who appears to have heartily disapproved the violent proceedings adopted against the Archbishop of Cambrai, wrote thus to the prelates who had particularly distinguished themselves as adversaries of Fénélon: *Peccavit excessu amoris divini, sed vos peccâstis defectu amoris proximi;* one of the most pungent reproofs, perhaps, which is to be found in all history.

[3] It is now known that the *Vie du Prince Eugène*, though written as if it were an autobiography in the first person, is the production of the Prince de Ligne. In this clever performance, the veteran is made to speak thus of the great preachers of his time: "Quand Bourdaloue me fait tout craindre, Massillon me fait tout espérer. Nous sommes nés la même année, et je l'ai connu à son entrée dans le monde, parfaitement aimable. Bossuet m'étonne; Fénélon me touche. Je les avais vus aussi dans ma jeunesse; et Marlborough et moi, nous avons rendu *au dernier* tous les honneurs possibles, quand nous avons pris Cambrai." (*Vie du Prince Eugène*, p. 225. Paris, 1810, 8vo.)

concerned itself for the welfare of the whole human family. "I love my family," said he, "better than myself; I love my country better than my family; but I love the human race better than my country." The humanity of Fénélon was not, however, confined to exaggerated speculations and impracticable generalities, which always suppose great ignorance of the details of human affairs. His politics were not the dream of a virtuous but fanciful mind. He had seen and judged both the court and the world; he was acquainted with the history of all ages; and he was endowed with an independence of spirit which raised him above the prejudices of his age and nation. In the different memoirs which he addressed to the Duke of Beauvilliers may be seen proofs of the wisdom of his views respecting the greatest interests, particularly the succession to the throne of Spain, the policy best suited to Philip V., the views of the allies, the conduct of the war, and the necessity of peace. The disastrous war of the succession having brought the theatre of action near to the archiepiscopal residence of Fénélon, afforded him an opportunity, after ten years' absence, of seeing the young prince whom he had formed, and who had just assumed the command of the French troops. It cannot be disguised, however, that, in the command of armies, the pupil of Fénélon fell far below the promise of his youth and the opinion of France respecting him. The letters of the archbishop to the Duke of Burgundy, at this decisive epoch, evince a severe frankness, and show the ascendency which the master had acquired over the mind of the scholar; so much so, indeed, as to create a suspicion that the young prince, though well informed, docile, and virtuous, was of too timid a genius. In these letters also severe judgments are pronounced on all the generals who then formed the hope of France. Fénélon, in fact, though he possessed great sweetness of disposition, had not a little of domination in his character. His ideas were absolute and decisive; the promptitude and force of his mind rendered his judgments energetic and inflexible. But the continual attention which he gave to the political interests of France in no degree diminished his zeal for the affairs of religion and the church; and those who have been accustomed to honour him as a philosopher, will perhaps be surprised to find him entering into all ecclesiastical discussions with an ardour equal to that of Bossuet himself. When the unfortunate disputes about Jansenism were, after a long interruption, revived, Fénélon wrote against men who did not imitate him in his respect for the court of Rome, and he soon found himself engaged in a controversy scarcely less animated than that which had taken place concerning Quietism.

The courtiers supposed that in acting thus Fénélon had views of ambition and flattery. But if he had desired to regain the favour of the sovereign, he employed, about the same period, a much more effectual method for accomplishing his object, by feeding at his own expense the whole French army during the disastrous winter of 1709. His aim in both cases was to serve religion and his country. The same sentiments dictated the view which he presented the following year of the evils of France, and also the project of associating the nation with the government, by convoking an assembly of the notables, a proposition remarkable in itself, and still more so when considered in connection with subsequent events. In the memoir which contains the exposition of this scheme, Fénélon shows that he had rightly estimated the strength and the weakness of despotism, as well as the salutary power of liberty. Meanwhile, an unexpected event appeared to accelerate the moment when the counsels of Fénélon were to govern France. The grand dauphin died, and the Duke of Burgundy, long oppressed by the mediocrity of his father, saw himself all at once brought close to the throne of which he was heir, and to the king, whose stay and support he now became. His virtues, freed from a jealous tutelage, had at length scope for action; and the pupil of Fénélon showed himself worthy of his master. Full of hope and joy, the latter wrote to the young prince, who, according to St Simon, reigned in advance, "Il ne faut pas que tous soient à un seul, mais un seul doit être à tous pour faire leur bonheur;" language which, we believe, has but rarely been addressed to the heirs apparent of thrones. But whilst Fénélon was devising plans for promoting the welfare of France, and advancing the glory of its future sovereign, all his hopes were blasted by the sudden death of the young heir of the old king, who remained unshaken amidst all the humiliations of his glory, and all the disasters of his family. Fénélon survived this event some time, and, notwithstanding his grief, laboured to prevent the evils incident to a long and inevitable minority. In several confidential memoirs which he wrote on this subject, we discover the novelty of his political views, and that spirit of liberty which, in his age, was not the least of its innovations. One of these papers is devoted to a discussion of the probabilities of the guilt of the Duke of Orleans, and whether he was actuated by an ambition which required other crimes besides that which had been laid to his charge; a memoir in which, without dwelling upon all the horrors of the popular reports, he judges severely the scandalous profligacy of the Duke of Orleans, and condemns his vices in the tone and language which it became a Christian bishop to assume. The last public discussion in which Fénélon engaged related to the bull *Unigenitus*, which, as is well known, gave rise to much controversy, and occupied his attention towards the close of his life. Malignity has supposed that the zeal of Fénélon in this matter was sharpened by an old grudge against the Cardinal de Noailles; but when the conduct of this virtuous and excellent man seems to be authorized by his duty, it is not necessary to explain it by reference to his alleged weaknesses. Faithful above all things to his episcopal character, he conceived himself bound to combat errors which he considered as calculated to disturb the consciences of men, and to interrupt the repose of the church. But his wine of life was now upon the lees. His friends, like the travellers on the bridge in the Vision of Mirza, had dropped off one by one, till the Duke of Beauvilliers alone remained to him; and when the latter was also removed by death, Fénélon followed him to the grave at the brief interval of four months. This great and good man expired on the 7th January 1715, at the age of sixty-four; and his death, which a slight fall had accelerated, was, like his life, that of a virtuous and exemplary Christian bishop. In the *Dissertations* prefixed to this work (vol. i. p. 335) the reader will find the characters of Fénélon and Bossuet ably contrasted, by Sir James Mackintosh.

The following list of the works of Fénélon includes every thing of any consequence which proceeded from his pen: 1. *Traité de l'Education des Filles*, 1681 and 1687; 2. *Traité du Ministère des Pasteurs*, 1688, in 12mo; 3. *Explication des Maximes des Saints*, 1697, in 12mo; 4. *Aventures de Télémaque*, 1699, the editions of which are innumerable; 5. *Dialogues des Morts, composés pour l'éducation d'un Prince*, 1712, in 12mo; 6. *Dialogues sur l'Eloquence en général, et sur celle de la Chaire en particulier, avec une Lettre à l'Académie Française*, 1718, in 12mo; 7. *Examen de la Conscience d'un Roi*, 1734; 8. *Lettres sur divers sujets, concernant la Religion et la Métaphysique*, 1718; 9. *Démonstration de l'Existence de Dieu, tirée de la connaissance de la Nature, et proportionée à la faible intelligence des plus simples*, 1713, in 12mo; 10. *Recueil de Sermons choisis sur différents sujets*, 1710, in 12mo; 11. *Œuvres Spirituelles.* There is no very complete edition of the works of Fénélon. The clergy of France undertook one some years before the Revolution, and entrusted the preparation of it first to the Abbé Gallard, and afterwards to the Abbé de Querbeuf; but, from whatever cause, in this collection of the writings of Fénélon, which appeared at Paris in nine volumes 4to, 1787–1792, the reader will seek in vain for those

on Quietism and Jansenism, his *Explication des Maximes*, and his *Mandements*. In the edition of the *Œuvres de Fénélon*, published at Toulouse, 1809–1811, in nineteen vols. 12mo, the life of Fénélon by Querbeuf has been introduced, together with four *Instructions Pastorales*, and an *Abrégé des Vies des anciens Philosophes*, which are not contained in the former edition. Some years after the death of Fénélon there appeared *Recueil de quelques Opuscules de M. de Salignac de Lamotte-Fénélon, archevêque de Cambrai, sur différentes matières importantes*, in 8vo, a rare volume, which is precious as containing a detailed catalogue or notice of all his works, reprinted in the edition of *Les Aventures de Télémaque*, published at Lyons in 1815. The éloge of Fénélon by D'Alembert will be found in the *Histoire des Membres de l'Académie Française* (tom. i. and iii.) That of Laharpe gained the prize proposed by the Academy, whilst the abbé obtained the *accessit*. But the most complete biographical account of this illustrious man is that given by M. de Bausset, formerly bishop of Alais, in his *Histoire de Fénélon*, 1808, in 3 vols. 8vo, reprinted the year following with corrections and additions. (J. B—E.)

FENTON, Sir Geoffrey, an eminent writer and statesman during the reigns of Elizabeth and James I., and brother to Edward Fenton, the navigator, who accompanied Sir Martin Frobisher in his expeditions, and was afterwards sent out independently to endeavour to discover a north-west passage. Sir Geoffrey appears to have received a liberal education, and certainly gave many proofs of his acquaintance with ancient and modern learning. He is best known, however, for his translation of the *History of the Wars of Italy* by Guicciardini, which he dedicated to Queen Elizabeth. He also published, 1. Certain Tragical Discourses, written oute of French and Latin, 1567, in 4to; 2. An account of a dispute at Paris, between two Doctors of the Sorbonne and two Ministers of God's Word, 1571; 3. An Epistle, or Godly Admonition, sent to the Pastors of the Flemish Church at Antwerp, exhorting them to concord with other Ministers; translated from the original of Antonio de Carro, 1578; 4. Golden Epistles, containing variety of Discourses, both moral, philosophical, and divine, gathered as well out of the remainder of Guevara's works, as other authors, Latin, French, and Italian, 1577. The familiar epistles of Guevara had been published in English by Edward Fellowes, in 1574; but Fenton's collection consists of pieces not contained in that publication, and, like his translation of Guicciardini, has risen in public estimation since the language and literature of the Elizabethan age have been more generally studied. In the capacity of queen's counsellor or secretary, Fenton served for a considerable time in Ireland, where his conduct appears to have given great satisfaction to his royal mistress. To his honour be it stated, he took every opportunity of impressing on the mind of the queen the important truth, that the safety and glory of her government in that island depended on her subjects enjoying the protection of equal laws. He died at Dublin, Oct. 19, 1606. (J. B—E.)

Fenton, *Elijah*, an English poet of considerable note, was born at Shelton, near Newcastle-under-Line, in Staffordshire, on the 20th of May 1683. Being the youngest of twelve children, he was destined for the church as a profession; and with this view he was admitted a pensioner of Jesus College, Cambridge; but having refused to take the oaths to government, he was obliged to quit the university without a degree, and forced to trust to his abilities for a subsistence. His first employment promised more than it afterwards realized. He accompanied the Earl of Orrery to Flanders in the capacity of private secretary, and returned with his lordship to England in 1705. Being thus left without employment, he became assistant in a school at Headley, in Surrey, and was soon afterwards appointed master of the free grammar-school at Sevenoaks in Kent. In 1710 he was prevailed on to give up the drudgery of teaching for the worse drudgery of political dependence; Lord Bolingbroke, who had persuaded him to take this unwise step, having, with characteristic recklessness, neglected his interest, and left him disappointed and in debt. But not long afterwards he was appointed tutor to Lord Broghill, only son of the Earl of Orrery; and when this engagement expired, he was, on the recommendation of Pope, employed to give private instructions to Mr Craggs, secretary of state, who, feeling his own want of literature, was anxious, with the aid of such an instructor, to supply the deficiencies of his education. His next engagement was with Pope himself. The success of the translation of the Iliad having induced the latter to undertake that of the Odyssey, he, in order to lighten the task, resolved to engage auxiliaries; and, with this view, retaining twelve books for his own share, he distributed the remaining twelve between Broome and Fenton. Of these, according to Johnson and Warton, Fenton translated the first, fourth, nineteenth, and twentieth; though the Earl of Orrery has asserted that he translated double the number of books which Pope has acknowledged.[1] In 1723 his tragedy of *Mariamne* was brought out, and performed with such success that the author's profits are said to have amounted to nearly a thousand pounds. The poetical merit of this tragedy is considerable; but the diction is too figurative and ornate for a dramatic composition, and accordingly it has not retained its place on the stage. In 1727 Fenton superintended a new edition of Milton's *Poems*, to which he prefixed a life, of which Johnson has spoken with commendation; and in 1729 he published a splendid edition of Waller, with notes. The latter part of Fenton's life was passed in tranquillity. By the recommendation of Pope, Lady Trumbull appointed him tutor to her son, first at home and afterwards at Cambridge; and when he had acquitted himself of the duties of this office, she still retained him in her family as auditor of her accounts, in which capacity he seems to have enjoyed his ease, and found leisure to pay frequent visits to his literary friends in London. He died at East Hampstead, Berkshire, on the 13th of July 1730, and was interred in the parish church, where his tomb has inscribed on it an epitaph written by Pope. Fenton, naturally indolent, was capable of greater things than he performed. His reputation as a poet rests chiefly on his *Mariamne*, and his share in the translation of the *Odyssey*, which the readers of poetry have never been able to distinguish from the portion executed by Pope himself; but to his *Miscellaneous Poems*, published in 1717, he has been indebted for a place amongst the English poets in Dr Johnson's collection. Of his morals and conversation the account is uniform. "He was never named," says Dr Johnson, "but with praise and fondness, as a man in the highest degree amiable and excellent. Such was the character given of him by the Earl of Orrery, his pupil; such is the testimony of Pope; and such were the suffrages of all who could boast of his acquaintance." (J. B—E.)

FEOD, or Feud. See Feudal Law.

FEOFFMENT, in *Law* (from the verb *feoffare* or *infeudare*, to give one a fief), the gift or grant of any corporeal hereditament to another, by delivery of the possession of the hereditament conveyed and evidenced by an instrument in writing, without which, since the 29th Car. II., cap. 3, there can be no valid feoffment. This mode of conveyance is now seldom resorted to; the 8th and 9th Vict., cap. 106, sec. 2, having enacted that all corporeal hereditaments lie in grant as well as in livery of seisin, which was previously required to perfect the conveyance by feoffment, and a "grant" or *concessio* is now substituted.

FERALIA, in *Antiquity*, a festival observed by the

[1] In a letter to Mr Duncombe, Lord Orrery says, "His reward was a trifle, an arrant trifle. He has even told me that he thought Pope feared him more than he loved him. He had no opinion of Pope's heart; and declared him, in the words of Bishop Atterbury, '*Mens curva in corpore curvo.*'"

Romans on the 21st of February (Ovid says the 17th), in honour of the manes of their deceased friends and relations. Varro derives the word from *inferi*, or from *fero*, on account of a repast carried to the sepulchres of such as had that day the last offices rendered to them. Festus derives it from *ferio*, on account of the victims sacrificed. Vossius again derives it from the epithet *fera*, cruel, frequently applied to death. Macrobius (*Saturnalia*, lib. i., cap. 13) refers the origin of the ceremony to Numa Pompilius. Ovid, in his *Fasti*, goes back for its institution as far as the time of Æneas. He adds, that on the same day a sacrifice was performed to the goddess Muta, or Dumb; and that the persons who officiated were an old woman and a number of attendant young girls.

During the continuance of this festival, which lasted eleven days, presents were made at the graves of the deceased, marriages were forbidden, and the temples of the gods were shut. Whilst the ceremonies continued, it was imagined that the ghosts suffered no punishments in hell, but that their tormentors allowed them to wander round their tombs, and to feast upon the meats which their surviving friends had prepared for them. During the feralia public feasts were sometimes given to the people at the tombs of the rich and great, by their heirs or particular friends.

FERDINAND, a name common among the royal families of some of the European states. Of the most distinguished or notorious of those who have borne this title we may mention Ferdinand I. of Austria, younger brother of Charles V., born 1503, died 1564; his grandson Ferdinand II. of Austria, who came to the throne in 1619, and died in 1637. Of the Neapolitan Ferdinands may be noticed—Ferdinand I., natural son of Alfonso V. of Aragon and Sicily,—born in 1423, died in 1494; his grandson Ferdinand II., who died in 1496; Ferdinand III., who became Ferdinand V. of Spain and Ferdinand IV. of Naples, or I. of the united kingdom of the Two Sicilies, born 1751, died 1825. Of the Spanish Ferdinands the most noted was Ferdinand II. of Aragon, the husband of Isabella of Castile, born 1453, died 1516; by whose union the Spanish monarchy was consolidated.

FÈRE, LA, a fortified town of France, in the department of Aisne, situated on an island of the Oise, near its confluence with the Serre, 16 miles N.W. of Laon. It has a large arsenal, a school of artillery, a powder mill, and saltpetre works. Pop. 3129. La Fère was taken by the allies on 24th February 1814.

FERENTARII, in *Roman Antiquity*, light-armed troops who fought with missile weapons. See ARMY, *Roman*, vol. iii., p. 631.

FERENTINUM (now *Ferento*), in *Ancient Geography*, a city of Etruria, on the northern slope of the Ciminian hills, about five miles from Viterbo, and the same distance from the banks of the Tiber. It is only noted as the birthplace of the Emperor Otho, and as possessing a very old and splendid temple of Fortune.

FERENTINUM (now *Ferentino*), in *Ancient Geography*, a city of the Hernici, about 48 miles from Rome, in a S.E. direction on the side of a hill rising immediately on the left of the Via Latina. It appears to have been at one time a Volscian city, but soon after the defeat of that people by the Romans in B.C. 413 it was made over with the adjoining territory to the Hernici. In the war which this latter people waged with the Romans in B.C. 361 it was taken by the Roman consuls, but so leniently dealt with, that when the Hernici rebelled for the third and last time, Ferentinum was one of the three Hernican cities that refused to join the revolt. In consideration of this they were allowed by the conquerors to retain their own laws, which they preferred to the Roman code. After the social war, however, the Ferentines accepted the franchise. The ancient remains at Ferentino possess considerable interest. They consist chiefly of the old walls built somewhat in the cyclopean style, a kind of citadel on the top of the hill, on which the cathedral now stands, and various other portions of Roman buildings.

FERETRIUS, a surname of Jupiter, as the subduer of enemies, and to whom the Romans consequently offered the *spolia opima*.

FERG, or FERGUE, FRANCIS PAUL, a landscape painter, was born at Vienna in 1689, and there learned the first principles of his art. He successively practised under Hans Graf, Orient, and Thiele. The last of these, who was painter to the court of Saxony, having invited him to Dresden to insert small figures in his landscapes, Ferg repaired to that city, whence he proceeded into Lower Saxony, and painted for the Duke of Brunswick and for the gallery of Salzdahl. From Germany he passed over to London, where he might have lived in esteem and affluence, had he not, by an indiscreet marriage, involved himself in difficulties from which he was never able to extricate himself, and which, it is said, terminated only by his death from actual starvation. This pleasing artist, Walpole observes, had formed a manner of his own from various Flemish painters, though resembling Poelemburg most in the enamelled softness and mellowness of his colouring; but his figures are greatly superior, every part of them being sufficiently finished, and every action expressive. He painted small landscapes, fairs, and rural meetings, with much natural truth; his horses and cattle are not inferior to those of Wouwermans; and his buildings and distances seem to owe their respective softness to the intervening air, not to the pencil. More faithful to nature than Denner, he knew how to omit exactness when the result of the whole demanded less precision in parts. The greater number of his works are in London and Germany; and the price they now bear is the best proof of their real merit. He also etched well with aqua fortis; and his works of that description are highly esteemed by print-collectors.

FERGUSON, ADAM, LL.D., a distinguished philosopher and historian, born June 20, 1723, at Logierait in the Highlands of Perthshire, of which parish his father was minister. This excellent man had a numerous family, of whom Adam was his youngest son, by Mary Gordon, daughter of Mr Gordon of Hallhead, in Aberdeenshire.

It is believed that Adam received the first part of his education at the village school of his native parish, and thence he was removed to Perth, where he is said to have made uncommon progress in classical literature.

Towards the end of 1738 he entered the university of St Andrews. The Greek class in St Leonard's College was at this time taught by Mr Francis Pringle, the ablest Greek scholar Scotland then possessed; and in his class Adam Ferguson was enrolled as a *ternar*—that is to say, one who pays the lowest rate of fees. It has been alleged that he was admitted one of the foundation bursars, having stood first in the list of successful competitors; but if so, the victory was not very splendid, as, of the twelve who entered the class along with him, not more than eight (being of the denomination of ternars) could have been permitted to share in the contest. Ferguson appears to have acquired little more at this seminary than a high admiration of the Grecian and Roman literature, to the beauties of which he was more nearly introduced than he had hitherto been. He obtained the degree of master of arts May 4, 1742, when he had nearly completed his nineteenth year. In November of the same year he entered the divinity hall; and he studied also a year or two at Edinburgh; but there his attention appears to have been chiefly given to pursuits not immediately connected with his clerical views. In 1745, though he had studied divinity only one-half of the usual period, the General Assembly permitted his ordination by the presbytery of Dunkeld, on the representation that young Ferguson had

been pitched upon as the fittest person, from his knowledge of the Erse language, to fill the office of chaplain to the Highland regiment (the 42d) under the command of Lord John Murray. He continued attached to this regiment till 1757; about the beginning of which year he was elected keeper of the Advocates' Library, on the resignation of the celebrated David Hume; but this office he relinquished in about a year.

In the course of 1757 Ferguson rendered himself conspicuous by the interest he took in the success of the tragedy of *Douglas*, written by his familiar friend the Rev. John Home, and by his published defence of the *morality of stage plays*. When Home resigned his living in June of that year, Ferguson and he retired to Braid, in the vicinity of Edinburgh, and there spent several months in study, enlivened by the intercourse of friendship. Ferguson's campaigning experience appears to have given him a relish for a migratory life: he delighted particularly in taking occasional excursions to the Highlands, and rambling amidst the lakes and forests of Rannoch, or among his native hills. It was here that the lofty enthusiasm of his spirit was nursed and matured; and it may be said that the dignity and ease of manner for which he was distinguished above most of the literary men of his country, was acquired not so much in the intercourse of polished society, as in the wilds of Athole. To use his own expressive words:—"If I had not been in the Highlands of Scotland, I might be of their mind who think the inhabitants of Paris and Versailles the only polite people in the world. It is truly wonderful to see persons of every sex and age, who never travelled beyond the nearest mountain, possess themselves perfectly, perform acts of kindness with an aspect of dignity, and a perfect discernment of what is proper to oblige. This is seldom to be seen in our cities or in our capital; but a person among the mountains, who thinks himself nobly born, considers courtesy as the test of his rank."

In 1759 Ferguson succeeded Dr John Stewart as professor of natural philosophy in the university of Edinburgh. He had paid comparatively little attention to physical science; yet with only four months to prepare his course, he acquitted himself to the satisfaction of all.

Ferguson was appointed in 1764 to the chair of moral philosophy, which had long been a favourite object of his ambition. He entered on his new duties with a degree of spirit and activity from which the most splendid results were to be anticipated. In his discourses he seldom had recourse to notes, but trusted to his memory;—a method of lecturing liable to abuse, and generally unsatisfactory to the student, though in his hands happily executed. His class was crowded by great numbers of gentlemen of high rank and official station, as well as by younger students. Within little more than a year after he commenced his labours as a lecturer on morals, he published his *Essay on the History of Civil Society*, which was received with great approbation. Mr Hume, in a letter, congratulates the author on the success of the book, adding that he had "met with nobody that had read it who did not praise it." About this time Ferguson married Miss Burnet, a young lady nearly connected with his mother's family, and still more nearly related to his intimate friend Dr Black. Soon afterwards he began to cultivate a farm in the parish of Currie, and, at a considerable sacrifice of private interest, gratified his taste for improvement, by transforming a barren heath into a scene which became distinguishd for beauty and fertility. All this time, however, he continued to conduct the business of his class with unremitted diligence, but seized every interval of leisure to collect materials for a history of the Roman commonwealth. Whilst thus engaged, he was solicited by the guardians of Charles, Earl of Chesterfield, to superintend that young nobleman's education, which had been much neglected. The negotiation was conducted through the mediation of Dr Adam Smith; and Ferguson was persuaded to accept the charge, though it necessitated the suspension of his lectures in the university; but having obtained leave of absence for the next session, he joined his young charge at Geneva in May 1774. This connection, however, terminated about twelve months afterwards. In the meantime he had very nearly been deprived of his office in the university, the town-council before the conclusion of the session having thought fit to declare the chair vacant. His friends in the university, particularly Drs Robertson, Blair, and Black, were exceedingly indignant at this decision, and endeavoured to get it reversed. As the council, however, seemed to have determined to fill up the place by a new election, it became necessary to apply to the Court of Session to put a stop to their proceedings.

After his return, he continued, as formerly, to divide his time between his literary and agricultural pursuits, and engaged occasionally in the political controversies which agitated the country during the progress of the American war. Besides his pamphlet in answer to Dr Price's observations on liberty, he communicated his views from time to time to Sir William Pultcney, and other members of parliament; and when it was resolved by government to send out commissioners to quiet the disorders in the colonies, he was appointed secretary to the commission. It is well known that the commissioners returned without accomplishing the object of their mission; but they had an opportunity of acquiring more useful information of the state and temper of the country than government had received in all the previous course of the contest. Whilst Dr Ferguson was absent during the session 1778-1779, his place was supplied by Dugald Stewart, who, about five years afterwards, was destined to succeed him in the chair of moral philosophy.

In 1780 Dr Ferguson was seized with an attack of apoplexy, which, though not violent, was nevertheless sufficient to alarm his friends. This formidable affection did not in the slightest degree impair the force of his understanding; and so abstemious did he afterwards become, as not only to secure himself against the recurrence of the disease, but to enjoy almost uninterrupted health for more than thirty years. As he could not now venture to lecture extempore as formerly, he wrote out his course, availing himself of the notes taken by some of the more intelligent of his former pupils. He was now (1783) busy in carrying his great historical work through the press. This was the *History of the Progress and Termination of the Roman Republic*, 3 vols. 4to; a book which not only delights by the clearness of its narrative and the boldness of its descriptions, but instructs and animates by profound and masterly delineations of character, as well as by the philosophical precision with which it traces the connection of events.

No longer able for the fatigue of public teaching, in the following year he resigned his chair in the university. He was succeeded by Dugald Stewart, then professor of mathematics; and an arrangement was made by which Dr Ferguson retained the salary. He now proceeded to revise the notes of his lectures on ethics and politics; and in 1792 they were published under the title of *Principles of Moral and Political Science*. Though composed under disadvantageous circumstances, this work contains an admirable view of the systems both of ancient and modern philosophers, particularly respecting the foundations of moral approbation, and the sources of private happiness and public security. Dr Ferguson, now in his seventieth year, resolved to pay a visit to the ancient metropolis of the world. He passed a short time at some of the principal cities of Europe, Berlin, Vienna, Florence, Naples, and Venice, and resided part of the winter of 1793 at Rome, in all of which places his reception was extremely flattering. He was elected a member of the Academy of Berlin, as well as of other learned societies. Upon his return to Britain in 1794, he took up

Ferguson. his residence at Nidpath Castle in Tweeddale, from which he soon removed to Hallyards on Manor Water, and in this agreeable retreat he spent the next fourteen years of his life. At last, however, when his sight and his hearing had in a great measure failed, he took up his abode at St Andrews. Here his strength gradually declined, but the vigour of his mind continued unimpaired to the last hour of his life. He died, after a short illness, Feb. 22, 1816, in the ninety-third year of his age, leaving three sons and three daughters.

In the various situations which it was his lot to occupy, he had uniformly conducted himself with a dignity and decision which bespoke the elevation and force of his mind. In private life his conversation was easy and elegant, and, among his intimate friends, enlivened by a fascinating gaiety and refinement of humour.

Among his writings are—*The Morality of Stage Plays seriously considered.* Edinb. 1757. *A Pamphlet on the Militia.* Lond. 1758. *The History of the Proceedings in the case of Margaret, commonly called Sister Peg.* Three editions. Lond. 1762. Another, 1777. *Analysis of Lectures on Mechanics.* Edinb. *An Essay on the History of Civil Society.* Lond. 1767. This book has passed through many editions, and has been translated into almost all the European languages. *Analysis of Pneumatics and Moral Philosophy.* Edinb. 1766. 12mo. *Institutes of Moral Philosophy*, 1769; 319 pages 12mo. Another edition, 1773; 294 pages. A translation of this edition into French was published at Geneva in 1775, and revised by the author. A third edition, enlarged, was published at Edinb. 1785; 317 pages, 12mo. This elementary work has been used as a text book in several foreign universities. Remarks on a pamphlet published by Dr Price, entitled *Observations on the Nature of Civil Liberty, &c.* Lond. 1776. *The History of the Progress and Termination of the Roman Republic.* Lond. 1783. 3 vols. 4to. A translation into German was printed at Leipsig in 1784. It has been translated into several other modern languages, and has passed through a number of English editions. *Principles of Moral and Political Science.* Lond. 1792, 2 vols. 4to. *Minutes of the Life and Character of Joseph Black, M.D.*, 1801. (Published in the *Transactions of the Royal Society of Edinburgh.*) *Biographical Sketch or Memoir of Lieutenant-Colonel Patrick Ferguson.* Edinb. 1817, printed, but not published for sale. He left behind him many papers; but a great mass of letters and other valuable documents had been indiscriminately destroyed by his direction some years before his death.

Ferguson, *James*, an eminent experimental philosopher, mechanist, and astronomer, was born at Keith, in Banffshire, in 1714, of parents in very humble circumstances. At an early age his extraordinary genius began to unfold itself. He first learned to read by overhearing his father teach his elder brother; and he had made this acquisition before any one suspected he had done so. He soon discovered a peculiar taste for mechanics, which first indicated itself on seeing his father use a lever; and having pursued this study a considerable time, even when very young, he at length made a watch in wood-work, from having once seen one. As he had no instructor, nor any help from books, everything he learned had all the merit of an original discovery; and such in fact he very naturally believed it to be. As soon as his age permitted he went out to service; but he met with hardships in this humble capacity which rendered his constitution feeble through life. Whilst he was servant to a farmer, whose goodness he acknowledges in the modest account of himself which he prefixed to his *Mechanical Exercises*, he frequently contemplated the stars; and he began the study of astronomy by constructing, from his own observations alone, a celestial globe. His kind master observing these marks of his ingenuity, procured him the countenance and assistance of some neighbouring gentlemen, by whose help and instructions he went on acquiring further knowledge, and was at length sent to Edinburgh. There, having obtained some notion of drawing, he began to take portraits in miniature, by which means he supported himself and family for several years, both in Scotland and England, whilst engaged in pursuing more serious studies. In London he first published some curious astronomical tables and calculations, and afterwards gave public lectures on experimental philosophy, which he repeated in most of the principal towns in England with general approbation. He was elected a fellow of the Royal Society without paying for admission; and he had a pension of L.50 per annum given him, unsolicited, by King George III. on his accession, who had heard his lectures, and who frequently sent for and conversed with him on curious topics. He also received several presents from his majesty, and from other patrons of merit. The degree of consideration which Mr Ferguson attained by the strength of his natural genius alone is in fact known to every one. In astronomy and mechanics he was pre-eminently distinguished, even in this nation of philosophers; and he might justly be styled self-taught, or rather heaven-taught; for in his whole life he had not received above half a year's instruction at school. He was a man of the clearest judgment and the most unwearied application to study; benevolent, gentle, and innocent in his manners as a child; humble, courteous, and communicative; and, instead of pedantry, philosophy seemed to have produced in him only diffidence and urbanity. Altogether his history is in its way one of the most interesting and instructive that has ever been recorded. He died in 1776, at the age of sixty-two.

The following is a list of Mr Ferguson's published works:—1. Astronomical Tables, and Precepts for calculating the true times of New and Full Moon, 1763. 2. Tables and Tracts relative to several Arts and Sciences. 3. An easy Introduction to Astronomy, 1769, 2d edition. 4. Astronomy explained upon Sir Isaac Newton's Principles, 1772, 5th edition. 5. Lectures on Select subjects in Mechanics, Hydrostatics, Pneumatics, and Optics, 1772, 4th edition. 6. Select Mechanical Exercises, with a short account of the Life of the Author by himself, 1773. 7. The Art of Drawing in Perspective made easy, 1775. 8. An Introduction to Electricity, 1775. 9. Two Letters to the Reverend Mr John Kennedy, 1775. 10. A third Letter to the Reverend Mr John Kennedy, 1775. Mr Ferguson also communicated several papers to the Royal Society, which were printed in their Transactions. In 1805, a valuable edition of his Lectures was published at Edinburgh by Dr, now Sir David, Brewster, in two volumes 8vo, with notes and an appendix, intended to adapt the whole to the actual state of science.

Ferguson, *Robert*, a Scottish poet who acquired a considerable share of celebrity at a very early period of life, was born at Edinburgh on the 5th of September 1750 or 1751. His father, whose name was William, paid court to the muses as well as the son; but he wisely relinquished the study of poetry for the more certain emoluments of trade and commerce, and was employed in different mercantile houses both in Edinburgh and in Aberdeen. He was an accountant in the Linen Hall when he died, but never acquired anything like an independent fortune.

The subject of this notice was of a weak and delicate constitution during infancy; so much so, indeed, that small hopes were entertained of his ever reaching the years of manhood. Yet such were the care and attention of his parents, that he was able to attend an English school by the time he was six years of age, when his progress was considered as very extraordinary; and it proved no less rapid at the High School of Edinburgh, which he attended for four years, acquiring a competent knowledge of the Latin tongue with very little labour or exertion. He then went to the grammar-school of Dundee, and in two years afterwards to the university of St Andrews, which his father preferred to Edinburgh, because a gentleman of the name of Ferguson had left two bursaries for the education of as many boys of the same name.

Ferguson's health was never at any time impaired by severe study; yet he kept alive at the university the opinion which had been entertained of him whilst at school, and he was decidedly the first mathematician of his own standing. He was patronized by Dr Wilkie, professor of natural philosophy, and also known as the author of the *Epigoniad*, who conceived an attachment for him, as much perhaps for

Feriæ.

his poetical as his mathematical talents. This kindness was repaid by Ferguson, on the death of Dr Wilkie, by a beautiful eclogue to his memory, written in the Scottish dialect.

He returned to Edinburgh when he had finished his studies, without having fixed on any particular employment; for although he was destined for the church by his father, on the death of the latter he paid but little attention to the expostulations of his mother. He was, however, induced to attempt the study of the law, in which, as might have been expected, he made no proficiency. He seems, however, to have turned a wishful eye to some sinecure place, in order to obtain which he paid a visit to a rich uncle who resided at Aberdeen, hoping that, through his influence, he might be settled in a manner suited to his merit. But in this expectation he was completely disappointed; for although his uncle at first showed him every mark of attachment, his fondness decreased by degrees; and in six months he desired his nephew in an abrupt manner to leave his house, without attempting to procure for him any kind of living.

His necessities at this period were so great that he copied papers in the commissary clerk's office for so much per sheet, an employment which he soon left in disgust. His exuberant wit, equalled only by his good nature, thoughtlessness, and social propensities, made all who knew him receive him with affection; but his powers of song and talents for mimicry often led him into the company of the dissipated, whose example could not fail to do him essential injury, and who had neither the power nor the inclination to provide for him through life. The irregularities in which he was thus led to indulge often awakened in him the reproaches of conscience; and the conversation of a minister, who understood his manner of life, appears to have made a deep impression on his mind. His remorse, indeed, soon afterwards assumed the appearance of absolute despair. His sprightliness entirely forsook him; but he gradually recovered from this despondency, and his health was at length fully restored. Soon afterwards his head was cut so severely by a fall, that he became delirious from the loss of blood; and in this condition he remained for some months, till the want of sleep and perpetual delirium put a period to his existence on the 16th of October 1774. He was buried in the Canongate churchyard. Over his grave a monument was erected by Robert Burns, who loved his genius, and naturally sympathized with failings akin to his own. Had Ferguson united prudence with his abilities, he would have no doubt risen to distinguished eminence in the literary world. His poems in the Scottish dialect have been very much admired by his countrymen; and when we reflect that they were composed in the intervals of dissipation, they must be considered as unequivocal evidences of his genius. (J. F. S.)

FERIÆ, in *Roman Antiquity*, holidays, or days upon which the people abstained from work. Proclamation was generally made by the herald, by command of the *Rex Sacrorum* or *Flamines*, that all should abstain from business; and whoever transgressed the order was severely fined.

The *feriæ* were of two kinds, public and private. The public *feriæ* were fourfold; first, *Stativæ*, which were kept as public feasts by the whole city upon certain immoveable days appointed by their calendar, as the *Compitalia*, *Carmentalia*, and *Lupercalia;* secondly, *Feriæ Conceptivæ*, which were moveable feasts, the days for the celebration of which were fixed by the magistrates or priests, as the *Feriæ Latinæ*, *Paganalia*, *Compitalia*, and others, which happened every year, though the days for observing them were left to the discretion of the magistrates or priests; thirdly, *Feriæ Imperativæ*, which were instituted by the mere command of consuls, prætors, or dictators, upon the gaining of some victory or other fortunate event; and, fourthly, *Nundinæ*. The *private* feriæ were holidays observed by particular persons or families, on several accounts, as birthdays, funerals, and the like. The *feriæ* belonged to the *dies festi*, and formed one division of them.

Feriæ Latinæ || Fermanagh.

FERIÆ *Latinæ*, a festival at which a white bull was usually sacrificed. On this occasion the Latin and Roman towns provided each a quantity of meat, wine, and fruits; and during its celebration the Romans and Latins swore eternal friendship to each other, taking home a piece of the victim to every town. The festival was instituted by Tarquinius Superbus, when, having overcome the Etruscans and made a league with the Latins, he proposed to build to Jupiter Latialis a common temple, at which both nations might meet and offer sacrifices for their common safety. At first the solemnity lasted but one day, but it was at different times extended to ten days. It was held on the Alban Mount, and celebrated with chariot races at the capitol, where the victor was treated with a large draught of infusion of wormwood.

FERISHTA, MOHAMMED CASIM, a celebrated Persian historian, was born in 1570, at Astrabad, on the shores of the Caspian Sea. While he was still a child his father was summoned away from his native country into Hindustan, where he held high office in the Deccan; and by his influence the young Ferishta received court promotion. In 1589 Ferishta removed to Bejapore, where he spent the remainder of his life under the immediate protection of the Shah Ibrahim Adil II. At the court of this monarch he died in 1611. Large portions of his History have been translated into English, particularly by Jonathan Scott. In the introduction a resumé is given of the history of Hindustan prior to the times of the Mohammedan conquest, and also of the victorious progress of the Arabs through the East. The body of the work contains much information on the geography and climate of Hindustan. Ferishta is reputed one of the most trustworthy of the oriental historians, and his work still maintains a high place as an authority.

FERMANAGH, an inland county in the south-western portion of the province of Ulster in Ireland, bounded on the north by Donegal and Tyrone, on the east by Tyrone and Monaghan, on the south by Cavan, and on the west by Cavan and Leitrim. According to the Ordnance Survey, it comprises an area of 714 square miles, or 457,195 acres, of which 289,228 are arable, 114,847 uncultivated, 6155 in plantations, 210 in towns, and 46,755 under water. In proportion to its area, therefore, Fermanagh has a greater quantity of land covered with water, and, in proportion to the arable land, a smaller extent of ground occupied by towns and villages, than any other county in Ireland.

Fermanagh was made shire ground in the eleventh year of the reign of Queen Elizabeth, and divided into the eight baronies of which it still consists, viz.

Baronies.	Contents in acres.			Annual valuation.		
Clanawley	75,286	3	35	£21,523	10	1
Clankelly	39,068	0	34	16,559	6	5
Coole	18,963	2	36	8,762	7	7
Knockninny	30,604	0	7	10,565	7	4
Lurg	83,109	2	33	27,217	17	6
Magherastephana	61,729	0	6	24,973	18	1
Magheraboy	94,171	1	13	31,905	3	1
Tirkennedy	54,353	3	3	£29,160	14	5
Total	457,286	3	7	£170,668	4	6

These baronies are subdivided into 23 parishes, all of which are in the diocese of Clogher excepting three, which are included in Kilmore diocese. The county is within the military district of Belfast, with barrack stations at Enniskillen and Belleek. The union workhouses are at Enniskillen, Lisnaskea, and Lowtherstown, and part of the county is comprised in the adjoining unions of Clones and Ballyshannon. The net annual value of property rated to the poor is L.195,864, and the amount of property valued under

the 6th and 7th Will. IV., cap. 84 (Griffith's valuation) is L.170,668.

The surface of the county of Fermanagh is uneven, exhibiting generally a succession of abrupt eminences of slight elevation. The borders towards Tyrone and Cavan, on the east, are mountainous. The north-western portion towards Leitrim presents one continuous mass of hills, many of them high, rough, and boggy. Of these Belmore Mountain, on the northern edge of Lower Lough Macnean, attains an altitude of 1312 feet. From the summit of the Toppid Mountain the greater part of Fermanagh, Tyrone, and Lough Erne may be seen. Quilca Mountain, partly in this county and partly in Cavan, rises to a height of 2188 feet. The south-eastern portion of the county is generally flat or but slightly elevated.

The great feature of the county is Lough Erne, which divides it nearly throughout its whole extent from north-west to south-east. This fine sheet of water forms two long lakes about five miles apart, connected by a fine river or strait, which, at about two-thirds of the distance from the Upper Lake, divides into two branches, leaving between them an island on which the principal part of the county town of Enniskillen stands. They are distinguished by the names of the Upper and Lower lakes. The former, or the more inland and southern lake, which lies between Belturbet and Enniskillen, is eleven miles in length, and from half a mile to six miles in width. The Lower and northern lake, which lies between Enniskillen and Belleek, is thirteen miles long, and from two to ten broad. The borders of both lakes are finely broken by numerous bays and inlets, formed by the projections of the surrounding hills, and both are studded with islands. Popular report makes the number of these equal to that of the days of the year; and, if all the detached points of rock or land visible above water were taken into the account, this number would not be much above the truth. There are not, however, more than 150 which deserve the name of islands. These are in general well formed for scenic effect, and some are planted, chiefly with ash and oak, to the water's edge. The largest of them, named Boa or Bow Island, containing about 1400 acres, is situated near the western extremity of the lake. But Devenish Island, near its eastern end, which comprises only about 80 Irish acres, of great fertility, is of much greater interest, from having on it one of the most perfect pillar towers in Ireland. Its height is 82 feet, and its circumference 49. It is built of cut stone, and finished at the top with a conical roof. Near the summit of the hill which forms the island is the abbey of St Mary's, of which the belfry staircase and some of the Gothic pillars still remain. At the foot of the hill is a church dedicated to St Molush; and in its vicinity are the remains of that saint's house, roofed and finished with cut stone. Within a few paces of the house is a stone trough, about six feet long, said to have been his bed, in which those affected with various complaints perform certain prescribed ceremonies, in the hope of obtaining relief. In the island of Ennism'saint are the ruins of an abbey founded by St Nevnid, whose festival is annually celebrated in it. The saint's bell, ornamented with gold and silver, is, says Archdall, still preserved in the island, and held in such veneration by the lower classes of people that it is often judicially tendered to swear on. "Next to the rock of Cashel," says Inglis, "I look upon Devenish Island to be the most interesting spot in Ireland, to those who are attracted by the union of the antique and picturesque." Belle-isle, containing about 112 acres, once the favourite residence of the Earl of Rosse, and celebrated as well for its natural beauties as for the taste displayed in its improvements, has been suffered to fall into such decay that scarcely a vestige remains of what it once was. Belle-isle is connected with the main land by a bridge. Lough Erne is navigable during the winter season through its whole extent to the fall of Belleek, within four miles of Ballyshannon. The navigation of the lake is chiefly carried on by small vessels called cotts, worked by oars; while a broad paddle at the stern serves instead of a rudder. A steamer of 20 horse power also plies between Enniskillen and the Ulster Canal at Wattle Bridge. Two other lines of inland navigation have been completed, one commencing at Lough Erne, and terminating at Lough Neagh; the other proceeding from the southern end of the Upper Lough Erne to the village of Leitrim, where it communicates with the Shannon. There are some smaller lakes in the county, the largest of which are Lough Melvin, on the borders of Leitrim, and Lough Macnean, on the confines of Cavan and Leitrim.

The only river of importance is the Erne, which rises in the county of Cavan, and after passing through Belturbet, falls into Lough Erne at its south-eastern extremity: thence, passing by Enniskillen, it enters the Lower Lake, at the north-western extremity of which it again narrows into a river, and, passing through Belleek, forms a fine water-fall, bursting out through a thick wood in a broad sheet: afterwards breaking over a ledge of shelving rocks, it foams through the arches of the bridge here thrown over it, after which it still maintains a rapid current, during a course of nine miles, in which it crosses many lesser ridges of rock, and at length precipitates its water down a noble cataract into the Atlantic at Ballyshannon. The other rivers are, the Arney, the Ballenclarogh, the Ballycassidy, the Clodagh, the Kish Water, the Moorlaugh, and the Sills; all of which, together with upwards of 50 smaller streams, contribute to feed the Loughs Erne.

The railway from Londonderry to Enniskillen is complete, and the lines from Dundalk and Newry are (1855) in progress. There is also a line of railway projected to Sligo from Enniskillen.

The geological structure of the county consists of yellow sandstone and carboniferous limestone, alternating with tolerable regularity. Red sandstone exists in Toppid Mountain. Yellow sandstone, well adapted for building, lies round the town of Enniskillen. Millstone grit occupies a district between the two sandstone formations. A beautiful species of brown marble is found near Florence-court, a limestone district; but it requires to be worked to a greater depth than at present in order to procure blocks and slabs free from flaws. Coal is said to have been found in Glengarron Hills; but there is no reason to suppose that it exists in such abundance as to become of importance in a commercial point of view.

Mineral springs are numerous. Rutty gives a list of 19, mostly sulphureous, but none are frequented by strangers.

The population of this county, according to the several authorities, the earlier of which cannot be relied on, has been stated as follows:—

1760, De Burgo	28,860
1792, Beaufort	71,800
1812, Parliamentary census	111,800
1821, Ditto	130,997
1831, Ditto	149,763

Baronies.	1841.			1851.		
	Males.	Females.	Total.	Males.	Females.	Total.
Clanawley	10,238	10,127	20,365	7,446	7,265	14,711
Clankelly	8.245	8,510	16,755	5,395	5,591	10,986
Coole	4,421	4,513	8,934	2,793	2,875	5,668
Knockninny	5,406	5,589	10,995	4,307	4,399	8,706
Lurg	13,536	14,052	27,588	9,990	10,397	20,387
Magheraboy	11,767	12,459	24,226	8,394	9,405	17,799
Magherastephana	11,046	11,516	22,562	8,492	8,881	17,373
Tirkennedy	12,323	12,733	25,056	9,990	10,387	20,377
Total	76,982	79,499	156,481	56,807	59,200	116,007

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The proportion of the number of males and females in this county is therefore about the average proportion for all Ireland, but above that of the inland counties, where, contrary to the general rule, the male population in several instances exceeds the female in number, which it never does in any of the maritime counties excepting Wicklow, in the neighbourhood of the metropolis. Between 1841 and 1851 the population of Fermanagh decreased 25 per cent., being 5 per cent. more than the average decrease for all Ireland in the same period, and nine per cent. more than the average for the province of Ulster.

The state of education, according to the returns made under the population act in 1821, and the Board of Education in 1824–26, was as follows:—

	Boys.	Girls.	Total.
1821	4032	2303	6335
1824–6	5845	3948	9793

Of the numbers in the latter return, 5283 were of the Established Church, 246 were Roman Catholics, 4204 Dissenters, whilst of the religious opinions of 60 there was no return. Eighteen schools, containing 1012 pupils, were supported by grants of public money; fifty-nine, containing 3433 pupils, by voluntary subscription; and the remaining 163 schools, containing 5348 pupils, were wholly maintained by the fees of the pupils. In 1854 there were 137 national schools in operation, attended by 8846 children—5275 boys and 3571 girls.

Near the town of Enniskillen is the well-endowed Royal School of Portora, founded in the reign of Charles II. According to the latest returns, there were 85 boys in the school; and in 1853 the rents received were L.1757, and the salaries paid to masters and assistants amounted to L.850.

Previously to the Union, the county was represented in the Irish parliament by four members, two of whom were returned for the county at large, and two for the borough of Enniskillen. At that period the number was reduced to three, one having been deducted from Enniskillen. No alteration in this arrangement was made by the Reform act. Since the Union, both town and county have been represented exclusively by members of the Tory party.

The state of the constituency at the four periods following, viz.—the first, before the disfranchisement of the forty-shilling freeholders, which took place on the passing of the Catholic Relief bill; the second, subsequent to that event, but previously to the passing of the Reform bill; the third, subsequent to the Reform act; the fourth, under the 13th and 14th Vict., cap. 69, was as under:—

	L.50.	L.20.	L.10.	40s.	Total.
1st Jan. 1829	252	183	—	6443	6878
1830	254	256	522	—	1032
1832	178	250	1001	—	1429
1853	—	—	—	—	4365

This county is almost exclusively agricultural. Farms vary from nine acres, chiefly under tillage, to large tracts for grazing.

The number of holdings of every class in 1852 and 1853 was as follows:—

	Not exceeding 1 acre.	From 1 to 5 acres.	From 5 to 15 acres.	From 15 to 30 acres.	From 30 to 50 acres.	From 50 to 100 acres.	From 100 to 200 acres.	From 200 to 500 acres.	Exceeding 500 acres.
1852	470	1,229	4,777	4,691	2,111	1,046	270	85	17
1853	466	1,167	4,845	4,654	2,088	998	276	83	17
Difference for 1853,	– 4	– 62	+ 68	– 37	– 23	– 48	+ 6	– 2	Nil.

The number of holdings exceeding one acre in extent amounted in 1852 to 14,226, and in 1853 to 14,128, being a decrease of 98, showing that this county is not one of the exceptions to the general practice latterly prevailing in Ireland of consolidating farms.

Much land has heretofore been let in the gross to middlemen, who sublet it to smaller tenants. Landowners of this description were distinguished by the name of ternybegs, or little landlords—from the Irish *tiernagh*, a prince, and *beg*, little. There is much land belonging to the see of Clogher in the county. Rents are sometimes paid in the mountainous districts in young cattle, butter, and yarn. Oats and barley are the kinds of grain chiefly raised; wheat is little grown. The manures are marl, limestone, limestone gravel, bog-mould, and bog-ashes. The marl is white and light, found under bogs and in banks. That about Florence-court is upon clay and gravel, with springs under it, which cause the marl to assume sometimes a tuberous form, coloured by oxide of iron.

The extent of land under crops of various descriptions from 1846 till the present year (1855) has been ascertained to be as follows:—

Years.	Corn, Beans, and Peas.	Potatoes.	Turnips.	Mangel Wurzel and other Green Crops.	Flax.	Meadow and Clover.	Total.
	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
1847	55,233	3,681	3,575	961	1,221	28,712	93,383
1848	55,852	9,185	4,606	1,481	1,131	30,170	102,425
1849	55,097	11,093	5,980	2,769	1,015	29,919	105,873
1850	52,698	13,736	5,280	1,982	1,283	28,685	103,664
1851	53,082	13,059	5,724	2,602	2,800	30,468	107,735
1852	48,709	13,594	5,407	2,534	2,537	32,784	105,565
1853	45,387	16,924	5,509	2,232	3,988	34,128	108,168
Average	52,294	10,181	5,154	2,080	1,996	30,709	103,830

The total produce of corn, beans, and peas in 1853 was 31,675 tons, or an average of 612 lbs. per head on the population, being 88 lbs. less than the average for all Ireland; the produce of the potato crop in the same year was 979,620 barrels; average per head 169 stones, the average production for the whole country being 140 stones. In the returns to an inquiry instituted into the comparative care or negligence prevailing in the cultivation of

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farms and the condition of road-sides as to weeds in the 32 counties of Ireland, Fermanagh is numbered 14 in the list of comparative freedom of farms from weeds, and 4 in that representing the comparative condition of the road-sides.

Timber is more general in Fermanagh than in some of the neighbouring counties. Beech grows to a large size. Ash is peculiarly abundant in Fermanagh as well as the adjoining counties of Cavan and Tyrone. About sixty years ago, in a mountain glen connected with the demesne of Florence-court, the upright variety of yew tree, known as the Irish yew, and a valuable object in pleasure-grounds from its elegant and compact growth, was first observed.

Concurrently with the decrease in the number of hold ings in Ireland, the quantity of stock has largely increased. The following table exhibits the quantity of live stock in this county from 1846, and its estimated value since 1849.

Years.	Horses.	Mules and Asses.	Cattle.	Sheep.	Pigs.	Goats.	Poultry.	Estimated Value.
	No.	No.	No.	No.	No.	No.	No.	£
1847	6,081	3,965	75,689	8,364	6,248	2,138	110,297	...
1848	6,510	4,338	81,710	8,871	8,089	2,229	151,622	...
1849	6,773	4,662	87,657	10,279	13,000	2,572	167,179	662,367
1850	6,446	4,527	88,040	10,260	14,745	2,722	180,594	664,665
1851	6,518	4,749	88,651	11,371	17,843	3,055	195,674	675,185
1852	6,416	4,521	85,102	12,555	16,853	3,461	191,728	650,981
1853	6,814	4,750	94,735	14,791	19,113	3,787	209,561	723,022
Average.	6,508	4,501	85,940	10,927	13,698	2,852	172,522	675,224

The trade of the county in butter is considerable, and the linen manufacture, of a coarse description of goods, chiefly for domestic use, is carried on to a small extent. The number of scutching mills in the county is 10, all of which are moved by water-power.

Fermanagh has few resident proprietors of high rank or large income, all members of the Established Church deriving their titles to their estates from Elizabeth, James I., or Cromwell. The English family of the Coles received large grants of land, and in 1760 John Cole was created Baron Mount Florence, and his successor Viscount and Earl of Enniskillen. The family mansion and demesne of Florence-court is among the most beautiful in the country. The mansion of Castle Coole, the seat of the Earl of Belmore, is built of Portland stone, in the Grecian style of architecture after a design by Wyatt, and at a cost of upwards of L.200,000. Among the many other fine residences in this county are Ely Lodge, the seat of the Marquis of Ely; Castle Caldwell; Riversdale; the modern Castle of Crum, the seat of the Earl of Erne; Castle Saunderson, &c.

A class of yeomanry is to be met with in this county who distinguish themselves by the character of being "as good Protestants as any in Ireland." These are farmers, who hold tracts of land of considerable extent, and were settled in the county when the right to the elective franchise was exclusively in the hands of Protestants. At that period Catholic tenants were often turned out of their farms, and sent farther up the mountains, to make room for the privileged class. The population of Fermanagh are in general a fine race, and Mr Foster remarks, that "the difference in the appearance of the people themselves in Leitrim and Fermanagh is as remarkable as the difference in dress and houses, and in the appearance of the country. At Ballinamore, in Leitrim, at a fair—with at least 10,000 men present, amongst whom I walked, and to whom I spoke, I scarcely saw a man above 5 feet 4 inches in stature, and I do not think I saw a dozen men in the whole fair so tall as myself. In the streets of Enniskillen every third man I met was a bigger man than myself."—*Letters on the Condition of the People of Ireland.*

Enniskillen is celebrated as a depot for obtaining recruits for the army. A regiment of horse was raised here in the time of King William, which is still distinguished by the name of the Enniskillen dragoons. This circumstance, together with the general habits and character of the peasantry, has tended to keep up a military spirit throughout the county.

The only large town in Fermanagh is the neat respectable-looking county town of Enniskillen, situate on an island having an area of sixty-two acres, formed by the river connecting the upper and lower Loughs Erne, and partly on the adjoining mainland on both sides, which communicate with each other by two bridges. It was founded in 1612 by William Cole, ancestor of the Earl of Enniskillen, to whom the chief portion of the town still belongs. It contains a parish church, a Roman Catholic chapel, Presbyterian and Methodist meeting-houses, and the usual buildings common to county and assize towns, but none of any great architectural pretensions. The corporation styled the "Portreve Free Burgesses and Commonalty of the Borough of Enniskillen," is now extinct, and its property vested in town commissioners. The population of Enniskillen in 1851 was 6000, and it was the only place in the county containing more than 2000 inhabitants.—(*Thom's Almanac*, &c.) (H. S—R.)

Fermat.

FERMAT, Pierre de, equally celebrated as a restorer of ancient mathematics, and an original author of modern improvements, was born at Toulouse about 1595. His public life was occupied by the active duties attached to the situation of a counsellor for the parliament of Toulouse, in which he was distinguished both for legal knowledge and for strict integrity of conduct. Though the sciences were the principal objects of his private studies, he was also an accomplished scholar, an excellent linguist, and even a respectable poet.

His *Opera Mathematica* were published at Toulouse, in two volumes folio, 1670 and 1679: they are now become very scarce. The first contains the *Arithmetic of Diophantus*, illustrated by a commentary, and enlarged by a multitude of additional propositions. In the second we find a *Method for the Quadrature of Parabolas* of all kinds, and a *Treatise on Maxima and Minima, on Tangents and on Centres of Gravity;* containing the same solutions of a variety of problems as were afterwards incorporated into the more extensive method of fluxions by Newton and Leibnitz; and securing to their author, in common with Cavalleri, Roberval, Descartes, Wallis, Barrow, and Sluse, an ample share of the glory of having immediately prepared the way for the gigantic steps of those illustrious philosophers. The same volume contains also several other treatises on *Geometric Loci*, or *Spherical Tangencies*, and on the *Rectification of Curves*, besides a restoration of *Apollonius's Plane Loci;* together with the author's correspondence, addressed to Descartes, Pascal, Roberval, Huygens, and others.

It was too much Fermat's custom to leave his most important propositions wholly undemonstrated; sometimes,

perhaps, because he may have obtained them rather by induction than by a connected train of reasoning; and in other cases, for the purpose of proposing them as a trial of strength to his contemporaries. The deficiency, however, has in many instances been supplied by the elaborate investigations of Euler and Lagrange, who have thought it no degradation to their refined talents to go back a century in search of these elegant intricacies, which appeared to require further illustration. It happened not uncommonly that the want of a more explicit statement of the grounds of his discoveries deprived Fermat, in the opinion of his rivals, of the credit justly due to him for accuracy and originality. It was thus that Descartes attempted to correct his method of *maxima* and *minima*, and could never be persuaded that Fermat's first propositions on the subject were unexceptionable. Fermat was however enabled to pursue his favourite studies with less interruption than Descartes; and the products of his labour were proportionate, as Lacroix remarks, to the opportunities he enjoyed, as well as to the talents he possessed.

There is a very ingenious proposition of Fermat which deserves to be particularly noticed, on account of the discussion that it not long ago excited among mathematical philosophers. He has demonstrated that the true law of the refraction of light may be deduced from the principle, that it describes the path by which it can arrive in the shortest possible time from any one point of its tract or course to another; on the supposition, however, that the velocity of light is inversely proportional to the refractive density of the medium: and the same phenomena of refraction have been shown by Maupertuis to be deducible, upon the opposite supposition with respect to the velocities, from the law of the minimum of action, considering the action as the product of the space described into the velocity. But the law of Fermat is actually a step in the process of nature, according to the conditions of the system to which it belongs in its original form; whilst that of Maupertuis is at most only an interesting commentary on the operation of an accelerating force. It was Newton who showed the necessary connection between the action of such a force and the actual law of refraction; demonstrating that all the phenomena might be derived from the effect of a constant attraction, perpendicular to the surface of the medium: and, except in conjunction with such a force, the law of Maupertuis would even lead to a false result. For if we supposed a medium acting on a ray of light with two variable forces, one perpendicular to the surface, and the other parallel to it, we might easily combine them in such a manner as to obtain a constant velocity within the medium, but the refraction would be very different from that which is observed, though the law of Maupertuis would indicate no difference; so that the law must be here applied with the tacit condition that the refractive force is perpendicular to the surface. In Laplace's theory of extraordinary refraction, on the contrary, the tacit condition is, that the force must *not* be perpendicular to the surface; so that this theory not only requires the gratuitous assumption of a different velocity for every different obliquity, which is made an express postulate, but also the implicit admission of the existence of a force, determinate in direction and in magnitude, by which that velocity is modified, and without which the law of Maupertuis would cease to be applicable. It may indeed be said, that the supposition of a medium exhibiting unequal velocities, and attracting the light perpendicularly, is unnatural, and that the law is the more valuable for not being applicable to it; but a mathematical equation is true even with respect to impossible quantities, and a physical law, however useful it may be, requires physical proof; and it will not be asserted that the law of Maupertuis has been or can be established by physical evidence sufficiently extensive to render it universal.

Fermat died at Toulouse in the end of 1664, or beginning of 1665, at the age of seventy. He left a son, Samuel de Fermat, who was a man of some learning, and published translations of several Greek authors. (T. Y.)

FERMENTATION. See Brewing, Chemistry, Wine-Making.

FERMO, the ancient *Firmum*, an archiepiscopal city of central Italy, capital of a cognominal delegation in the Papal States, 34 miles S. by E. of Ancona. The city is surrounded by old walls, and has besides the cathedral numerous churches and convents, a university, and two fine collections of statuary and paintings. Lactantius and Galeazzo Sforza were born here. The port, Porto di Fermo, is situated on the Adriatic, about four miles from the town. The harbour is small, but has some trade in corn, silk, and woollens. Pop. 7000.

FERMOY, a market-town of Ireland, county of Cork, situated on the Blackwater river, 20 miles N.E. of Cork, and 137 miles from Dublin. Previous to 1791, Fermoy was a mere hamlet, but about that time the proprietor, Mr Anderson, commenced a series of improvements; and shortly afterwards infantry and cavalry barracks were erected, commanding an important pass of the Blackwater, which is one of the principal northern approaches to Cork. The river is here crossed by a stone bridge of 13 arches, erected in 1689. Besides the parish church and Roman Catholic chapel—both elegant edifices—Fermoy has also a Roman Catholic college, a nunnery, court-house, theatre, bridewell, and workhouse. It has likewise several extensive flour mills, two paper mills, and a considerable trade in flour and agricultural produce. Market-day, Saturday. Pop. (1851) 5844, besides 2682 in workhouse.

FERN or Farn Islands, a group of small islets and rocks, 17 in number, lying off the coast of Northumberland, but included in the county of Durham. There are two lighthouses on these islands. It was here in 1838 that Grace Darling and her father in stormy weather rescued the passengers of the "Forfarshire" steamer. The Fern Islands are frequented by immense numbers of sea-birds.

FERNANDO DE NORONHA, an island in the South Atlantic, lying about 70 leagues from the coast of Brazil. It is about 20 miles in circumference, and the surface is rugged and is mountainous. It has several harbours defended by forts, and serves as a place of banishment for criminals from Brazil. N. Lat. 3 56., W. Long. 32. 28.

FERNANDO PO, or Fernão do Pão, an island on the W. coast of Africa, lying in the Bight of Benin, about 20 miles from the mainland, in N. Lat. 3. 25., E. Long. 8. 50. It is about 44 miles in length from N.N.E. to S.S.W., and about 20 in breadth. The coasts are steep and rocky, and the interior is mountainous. A ridge of mountains towards the centre of the island rises to the height of 8000 feet, and is terminated at each extremity by a peaked mountain,—the one at the N. extremity attaining a height of 10,700 feet. The southern extremity of the island is also intersected by several steep mountains, varying from 1000 to 3000 feet. These mountains are covered, most of them to their summits, together with the intervening valleys, with dense forests of shrubs and lofty trees of luxuriant growth. The rocks are of volcanic origin; and the soil is rich and fertile, producing rice, sugar-cane, cotton, tobacco, yams, palms, &c. Sheep, goats, fowls, turtle, and fish, are abundant. The climate is salubrious, though the rainy season lasts from May to December, and is succeeded by a season of dense fogs. The harbours are small, the largest being Port Clarence on the northern shore. This island was discovered in 1471 by a Portuguese navigator, whose name it bears. It was taken possession of by Spain in 1778, but abandoned in 1782. The English in 1827 formed a settlement here, but relinquished it in 1834; the Spaniards resumed possession of it in 1844, and have given it the name of

Puerto de Isabel. The native population is estimated at about 15,000.

FERNEL, Jean François, a distinguished French physician, was born at Clermont in 1497. His immense general erudition, and the skill and success with which he sought to revive the study of the old Greek physicians, gained for him a great reputation, and ultimately the office of physician to the court. He practised with very great success, and at his death in 1558 left behind him an immense fortune. His principal works are, *Monalosphærium, sive Astrolabii genus, generalis Horarii Structura et Usus*, Paris, 1526; *De Abditis rerum Causis*, a work which went through thirty editions in a short time; *Medicina, ad Henricum II.*, &c., which was also very frequently reprinted; and *Consiliorum Medicinalium Liber*, Paris, 1582, a work which enjoyed a similar distinction.

FERNEY, a village in the arrondissement of Gex, department of Ain, France, 5 miles N.W. of Geneva. It is celebrated as having been for nearly 20 years the residence of Voltaire, and hither the greatest personages of the time eagerly resorted to pay their respects to that great genius. Previous to his purchase of the estate in 1758, Ferney was a wretched hamlet, consisting of a few hovels. He formed it into a neat little town, colonized it with industrious artizans, chiefly watchmakers from Geneva, and drained and planted the adjacent grounds. The château in which he resided has been so much altered by the present proprietor, that scarcely a relic of Voltaire now remains.

FERNS, *Filices*. See Botany.

FEROE ISLES. See Faroe.

FERONIA, an ancient Italian divinity (related to Tellus), the patroness of woods and orchards, and the guardian deity of freedmen. Several groves were consecrated to Feronia; and in these, on the festivals of the goddess, great markets were held. Her chief sanctuary was at Terracina, near Mount Soracte. Strabo relates, that those who sacrificed to Feronia walked barefoot on burning coals without being hurt. She is variously represented;—viz. as the goddess of liberty; of commerce and traffic; or as a goddess of the earth.

FEROZEPOOR, a town of Hindustan, and the chief place of a British district of the same name, which, upon the demise of its native ruler in 1835, lapsed to the British government as the paramount power. Since its occupation by its new masters great improvements have been effected. Both town and fort were, in the first instance, new-modelled and rebuilt of burnt brick; the streets have now greater width, and the colonnaded rows of shops exhibit the aspect of an extensive mercantile city. From its position Ferozepoor is well adapted for a commercial entrepôt, being situate near one of the great ferries over the Gharrah, and possessing the means of easy communication with the lower part of the Punjaub and Sinde, afforded by that river and its recipient the Indus. It was here that in November 1838 the interview took place between Runjeet Singh, then ruler of the Punjaub, and Lord Auckland the governor-general, on which occasion 10,000 men rendezvoused at the town previously to their advance to the invasion of Afghanistan. Ferozepoor is distant N.W. of Calcutta 1181 miles. Lat. 30. 55., Long. 75. 35.

FEROZESHAH, in Hindustan, a village situated a few miles from the left bank of the river Sutlej. Here, on the 21st December 1845, the camp of the Sikhs was attacked by the British army under Sir Hugh Gough (afterwards Lord Gough), and Sir Henry Hardinge (afterwards Lord Hardinge). The camp was formidably intrenched, and the contest was most severe. The fall of night did not altogether put an end to it, the guns of the assailants continuing to play on part of the enemy's intrenchments. On the 22d fighting was resumed, and the final result was a complete triumph to the British arms; but it was dearly purchased. The loss of the victors was immense; and among the killed were included some of the best and most distinguished officers of the British army. Through a mistake, the force employed in the attack was lamentably deficient in the two important arms of war, cavalry and artillery; which led to a prolongation of the conflict, and might have affected its termination. Lat. 30. 52., Long. 74. 50.

FEROZPOOR, a town of Hindustan, and the principal place of the district of the same name, in the British province of Goorgaon. The jaghire or feudal possession of Ferozpoor, containing an area of about 140 square miles, was bestowed in the beginning of the present century by Lord Lake upon the Nawaub Ahmed Buksh Khan, in consideration of certain diplomatic services rendered by him at the court of the ruler of Alwur. The Nawaub, dying in 1827, was succeeded by his son Shumsooddeen Khan. The two younger brothers of Shumsooddeen having well-founded claims upon a portion of the inheritance, Mr William Fraser, the British political agent at Delhi, exerted himself to induce the British government to make a partition in their favour. The result was the murder of Mr Fraser at Delhi, by the hand of an assassin in the employ of Shumsooddeen. This took place in October 1835. Shumsooddeen was brought to trial for the murder, and being duly convicted, was hanged; and his possessions being declared forfeited, Ferozpoor was incorporated with the British province of Goorgaon. The town is distant N.W. from Calcutta 895 miles. Lat. 27. 47., Long. 77. 1.

FERRARA, a celebrated city of the Papal States, capital of a cognominal legation, and the seat of an archbishopric, is situated in a low marshy plain on the left bank of the Volano, an arm of the Po, about five miles S. of the main channel. Ferrara is said to have had its origin about the middle of the fifth century, and was walled by the exarch of Ravenna in 585. In 657 it was made the seat of a bishopric, and of an archbishopric in 1735. In 1240 the family of Este became hereditary princes of Ferrara, and continued to hold it sometimes under the pope and sometimes as independent princes, till the reigning branch became extinct in 1597, when it was finally attached to the papal dominions. During the latter part of this period Ferrara was the seat of one of the most polished and refined of the Italian courts, and is said to have contained more than 80,000 inhabitants. Ferrara receives an additional lustre from its connection, about this time, with the names of Ariosto, Tasso, and Guarini. In the fifteenth century it was famous for its school of painting, which ranked as one of the first in Italy. Calvin and other French reformers found an asylum here when driven from France in the early part of the sixteenth century. In 1796 Ferrara was taken by the French, and became the capital of the department of Bas-Pô, but was restored to the pope in 1814. The city has long been in a state of decay, and is only interesting to the traveller from its associations with the past: grass now grows on its once well-trodden streets, and many of its splendid palaces are uninhabited, and rapidly going to decay.

> "Ferrara! in thy wide and grass-grown streets,
> Whose symmetry was not for solitude,
> There seems, as 't were, a curse upon the seats
> Of former sovereigns, and the antique brood
> Of Este, which for many an age made good
> Its strength within thy walls, and was of yore
> Patron or tyrant, as the changing mood
> Of petty power impelled, of those who wore
> The wreath which Dante's brow alone had worn before."
>
> *Childe Harold*, iv. 35.

Being the most northern city in the Papal States, Ferrara is strongly fortified, and is defended on the western side by a pentagonal citadel, which, in accordance with the treaty of Vienna, is garrisoned by Austrian troops. The old ducal palace, now the residence of the legate, stands in the middle

of the town, and is surrounded by wet ditches, and flanked with towers. The cathedral, a vast untasteful edifice, consecrated in 1135, is adorned with sculptures, bronze statues, frescoes, and paintings. Many of the other churches contain many finely sculptured monuments and paintings by the great masters of the schools of Bologna and Ferrara. The theatre is one of the largest and finest in Italy. The university, founded in 1390, and revived by Leo XII., is noted for its faculties of law and medicine. The public library, founded in 1740, contains about 80,000 printed volumes and 900 manuscripts, among which are the manuscripts of the works of Ariosto and Tasso. The house in which Ariosto lived is still in existence. The bust on his tomb in the church of the Benedictines was, towards the middle of the last century, struck by lightning, and the iron laurels that wreathed its brow were melted; a circumstance alluded to by Lord Byron in *Childe Harold* (iv. 41). In 1801 the remains and tomb of Ariosto were removed with great pomp to the public library, and here are also his arm-chair and ink-stand. In the lunatic hospital of Santa-Anna a small room on the ground-floor is still shown as that in which Tasso was confined. In the principal square are bronze statues of two of the dukes of Ferrara. The manufactures and trade of the town are inconsiderable. Pop. about 25,000, of whom about 2000 are Jews, who reside together in the *ghetto* or Jews' quarter.

The Legation of Ferrara is the most northern in the papal dominions; and is bounded on the N. by the main branch of the Po, which separates it from Austrian Lombardy, W. by the duchy of Modena, S. by the legations of Ravenna and Bologna, and E. by the Adriatic. The surface is generally flat, and being in many parts below the level of the Po it is protected from inundations by strong embankments along the river. (See Po.) A considerable portion of the eastern part of the legation is constantly under water. Area 1042 square miles. Pop. (1850) 229,862.

FERRIER, Barbara, a distinguished Scottish novelist, was born at Edinburgh in 1782. Her father was associated with Sir Walter Scott as one of the clerks of the Court of Session, and this connection opened up to Miss Ferrier the best literary society of her birth-place. She made her *début* in literature in the novel of *Marriage* published anonymously in 1818. Though the success of this tale was very flattering, she never dropped the mask, and her subsequent novels, *The Inheritance*, and *Destiny or The Chieftain's Daughter*, given to the world respectively in 1824 and 1831, also appeared without the author's name. This circumstance led Sir Walter, when alluding to her in his *Tales of My Landlord* as a skilful delineator of Scottish life and character, to describe her as his "sister shadow, the author of the very lively work entitled *Marriage*." At a later period, talking from a more intimate knowledge, he praised her as "a gifted personage, having, besides her great talents, conversation the least *exigeante* of any author, female at least, whom he had ever seen among the long list he had encountered with; simple, full of humour, and exceedingly ready at repartee, and all this without the least affectation of 'the blue-stocking.'" A perusal of Miss Ferrier's works would lead the reader to expect in her the very character limned by her great friend in this brief sketch. All her works show a keen insight into human nature, especially in its foibles and oddities, great breadth of comic humour, and an exhaustless fund of racy and caustic wit. Character-drawing, however, is her forte. All her *dramatis personæ* are vigorously, sometimes even deeply, drawn. Far more truly than it was said of Miss Burney by Dr Johnson, may it be said of Miss Ferrier, that she is a complete character-monger. Even her earliest tale, confessedly weak in the matter of plan, is a perfect gallery of portraits. The plots of her later novels are much more carefully wrought out, and, with equal merits of detail, far more artistic in their general effect. The dialogue is well maintained, spirited, and natural throughout. Scotch is freely used, and besides being peculiarly pithy and terse, is so idiomatic, that on any but a native ear much of its charm must be thrown away. As Miss Ferrier wrote neither for fame nor money, she was saved from all the annoyances that beset the literary career. Her circumstances placed her above the small jealousies of literary rivalry, and enabled her to hold back her works until they had received the highest polish she could give them. The pains and toil of this process were cheerfully undergone by the novelist. Long before her death she had the satisfaction of seeing that she had not toiled in vain. Her works have taken their place in the permanent literature of the country, and vindicated their author's title to rank with the Edgeworths and Austens of the first half of the nineteenth century.

Miss Ferrier spent the greater part of her long life in Edinburgh, in the enjoyment of peace and quiet, and in the performance of every good and virtuous deed. She died in November 1854, in the seventy-third year of her age.

FERROL, a sea-port town of Spain, province of Coruña, and one of the first naval arsenals in the kingdom, is situated on the N. arm of the Bay of Betanzos, 12 miles N.W. of the town of Coruña. The harbour, which is one of the best in Europe, is deep, capacious, and secure; but the entrance, which is a strait about two miles in length at the narrowest part, only admits one ship at a time, and is commanded on either side by strong forts. The town is protected on the land-side by a wall, on which 200 cannon might be mounted. The dockyard is divided into two parts, the outer being the smaller, and the whole occupying a space of more than 115,000 square yards. Behind the inner dock are the dwellings of the operatives, and in the N. angle are the foundries, rope-walks, and magazines. They are all, however, as well as the arsenal, in a neglected and ruinous condition. The old town is very irregular, but the new town is a parallelogram of seven streets in width by nine in length, intersecting each other at right angles, and has two squares, in one of which is a fountain, erected in 1812 in honour of Cosme Churruca, a naval officer, killed at Trafalgar. The Alameda, or public walk, is between the new town and the Astillero or dockyard. Ferrol contains two hospitals, three large churches, a monastery, consistory, prison, naval barracks, academies of navigation and mathematics, and has 16,641 inhabitants.

FESTUS, Sextus Pompeius, a celebrated Latin grammarian of uncertain date, but who probably flourished in the third century of the Christian era. His celebrated work *De Verborum Significatione*, a valuable treatise on many obscure points of grammar, mythology, and antiquities, was an epitome of the voluminous work of M. Verrius Flaccus, a grammarian who flourished in the reign of Augustus. In compiling this abridgment Festus had made a few alterations, and inserted some critical remarks of his own, besides omitting altogether such ancient Latin words as had long been obsolete. These he discussed in a separate work now lost, entitled *Priscorum Verborum Libri cum Exemplis*. Of Flaccus' work only a few fragments have come down to us. Of Festus' epitome only one original copy is known to be in existence, and that in a very imperfect form. After passing through very many vicissitudes, it found a temporary shelter in the Farnese Library at Parma, whence in 1736 it was taken to Naples, where it now lies. At the close of the eighth century Paulus Diaconus, who happened to possess a copy of Festus' work, epitomized it; but as he was himself a poor scholar, he allowed countless errors to creep into his abridgment. From this work of his, and the solitary mutilated copy of the original which still survives, some of the most distinguished scholars of modern Europe have attempted to reconstruct the important treatise of Festus. Of the early editions the best are

those of Scaliger, published in 1565, and of Fulvius in 1581, by both of which editors many of the blanks are filled up by conjecture. But by far the best of existing editions is that of K. O. Müller, Leipzig, 1839. Festus' work is in many respects extremely valuable. He gives not only the meaning of every word, but also its etymology; and this work, fragmentary as it is, has thrown much light on the language, mythology, and antiquities of ancient Rome.

FETIALES, or FECIALES, in *Roman Antiquity*, a college of priests, whose duty it was, when any dispute sprang up between their countrymen and a foreign state, to demand satisfaction, decide if war were necessary or advantageous, and perform the solemn rites consequent on the declaration of hostilities or the ratification of peace. The institution of this college is attributed by common consent to Numa. They are believed to have been twenty in number, and to have been originally chosen from the noblest families. Their office lasted for life, and their persons were deemed peculiarly sacred. The etymology of the word is very uncertain. By some it is derived from the same root with *fidus* and *fœdus;* by others from *ferio* or *facio;* while some modern scholars trace it to the Greek φημί. A detailed account of their principal duties will be found under CLARIGATIO.

FETICHE, the symbolic representation of the tutelary deity worshipped by the negroes of Africa. Anything appears to serve for a fetiche; as a tree, a stone, the beak of a bird, the fin of a fish, &c. See CONGO, vol. vii., p. 246.

FEU, in *Scots Law*, is used in contradistinction to ward-holding or military tenure, to signify that holding where the vassal makes a return in grain or money in lieu of military service. The person so holding is termed a *feuar;* and the rent paid *feu-duty*.

FEUD, or DEADLY FEUD, among our Saxon ancestors, was used to signify an irreconcilable enmity, to be satisfied only with blood. Such enmity and revenge were sanctioned by law. Thus when a man was killed, if no pecuniary satisfaction were made to his kindred, it became lawful for them to avenge themselves by slaying his murderer.

FEUDAL LAW is that system of Gothic jurisprudence which reached its full maturity during the middle ages, and which long continued to regulate the tenure of real property in the principal countries of Europe. The relations of lord and vassal have undergone very essential changes, the knight no longer holds his estate on the condition of military service, and most of the feudal incidents have been gradually superseded as unsuitable to the spirit of modern times; but this law has left many deep traces behind it, and is so closely interwoven with our national institutions, that it could not without great difficulty be entirely disentangled. Where the substance has almost totally vanished, the form is in some instances not very advantageously retained.

Of the word feudal many different etymologies have been proposed. According to Somner, who treads in the steps of Selden and Spelman, feud is a German compound, which consists of *feh, feo,* or *feoh,* signifying a salary, stipend, or wages, and of *hade, head,* or *hode,* signifying quality, kind, or nature; so that, in its primary acceptation, feudum, or land held in fee, was such as was held in *fee-hode,* by contraction *feud* or *feod;* that is, in a stipendary way, with the acknowledgment of a superior, and a condition of returning some service for it, on the withdrawing of which, the land was revertible to the superior.[1] Sir Martin Wright has remarked that "this etymon not only suggests the most probable account of the word, but gives us the clearest description of the thing itself."[2]

The origin of the feudal system is a question which has been long and much agitated, and different authors have arrived at very different conclusions. "It has puzzled the learned," says Dr Stuart, "to discover the nation of the barbarians which first gave a beginning to fiefs. No inquiry could be more frivolous. In all of them they must have appeared about the same period; and they prevailed in all of them in consequence of the similarity of their situation on their conquests, and in consequence of their being governed by the same customs. It is not therefore to the principle of imitation that their universality is to be ascribed."[3] But the most comprehensive and the most decided opinion is that of Mr Pinkerton, who avers that "the feudal system, about which so much noise is made, is the natural fruit of conquest, and is as old in the world as conquest. A territory is acquired, and the state, or the general, bestows it on the leaders and soldiers, on condition of military service, and of tokens acknowledging gratitude to the donors. It was known in the Greek heroic ages. It was known to Lycurgus, for all the lands of Sparta were held on military tenure. It was known to Romulus, when he regulated Rome. It was known to Augustus, when he gave lands to his veterans, on condition that their sons should, at fifteen years of age, do military service. The reason it did not preponderate and corrupt in Greece and Rome was, that it was stifled by the necessary effects of cities, as above mentioned. In Persia, where there were no cities of any power or privilege, it preponderated and corrupted at an early period. The feudal system, whether in its original democracy, or corrupted into aristocracy, must limit the power of kings; for men who hold their possessions on military service, must of course have arms in their hands: and even in absolute governments the soldiers are free, witness the prætorian bands and armies of imperial Rome, and the Turkish janisaries. By the feudal system every man held arms and freedom in his hands. Montesquieu has begun his account of the feudal system with that of the ancient Germans, given by Tacitus,[4] and prides himself in leaving off where others began. A writer more profound would leave off where Montesquieu begins."[5] This last sentence may be considered as a modest attempt at impressing the reader with an opinion that Pinkerton is a writer more profound than Montesquieu; but, without acquiescing in all his notions, we may at least admit that of the feudal system many authors have taken a view much too narrow and limited. The peculiar relation of lord and vassal, of territorial grants and the tenure of military service, is doubtless to be traced in very remote ages and countries. All the feudal incidents it may often be difficult to detect; but wherever we find portions of land granted to military vassals under the condition, express or implied, of following the standard of their lord, we there find the most essential characters of the feudal system. The order of chivalry may not be found completely engrafted: there may be no denomination equivalent to that of knight, and such incidents as those of relief, aids, and wardships, may be wanting; but instead of a faint analogy, there may still be a very close resemblance between one system and another.

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[1] Somner's Treatise of Gavelkind, p. 106. Lond. 1660, 4to.

[2] Wright's Introduction to the Law of Tenures, p. 4.

[3] Stuart's View of Society in Europe, p. 218. Edinb. 1778, 4to.

[4] Montesquieu de l'Esprit des Lois, liv. xxx. chap. ii. seq.—Dr Stuart commences his researches from the same point. "In the manners of the ancient Germans," he remarks, "I have found the source and spirit of the feudal law." See likewise the elaborate work of Meyer, Esprit, Origine et Progrès des Institutions Judiciaires des principaux Pays de l'Europe, tom. i. p. 4. Haye, 1819–23, 6 tom. 8vo.

[5] Pinkerton's Dissertation on the Origin and Progress of the Scythians or Goths, p. 139. Lond. 1787, 8vo.

Feudal Law.

"It has been very common," says Mr Hallam, "to seek for the origin of feuds, or at least for analogies to them, in the history of various countries. But, though it is of great importance to trace the similarity of customs in different parts of the world, because it guides us to the discovery of general theorems as to human society, yet we should be on our guard against seeming analogies, which vanish away when they are closely observed. It is easy to find partial resemblances to the feudal system. The relation of patron and client in the Roman republic is not unlike that of lord and vassal, in respect of mutual fidelity; but it was not founded on the tenure of land nor military service. The veteran soldiers, and, in later times, some barbarian allies of the emperors, received lands upon condition of public defence; but they were bound not to an individual lord, but to the state. Such a resemblance to fiefs may be found in the zemindaries of Hindostan, and the timariots of Turkey. The clans of the Highlanders[1] and Irish followed their chieftan into the field; but their tie was that of imagined kindred and respect for birth, not the spontaneous compact of vassalage. Much less can we extend the name of feud, though it is sometimes strangely misapplied, to the polity of Poland and Russia.[2] All the Polish nobles were equal in rights, and independent of each other; all who were less than noble, were in servitude. No government can be more opposite to the long gradations and mutual duties of the feudal system."[3]

Macieiowski, a learned civilian of our own age, discovers manifest vestiges of the feudal system among the ancient inhabitants of Tuscany.[4] To the ancient relation of patron and client, the origin of feudal tenures was traced by Budæus, one of the first lawyers in modern times who applied a very ample store of classical erudition to the illustration of Roman jurisprudence.[5] The same opinion was adopted by Zasius, but it has deservedly been rejected by most of the subsequent commentators; nor is it easy to acquiesce in the speculation of Connanus, who deduces the principles of this law from the fraternities of Soldurii among the ancient Gauls.[6] The assignment of lands by the Roman emperors makes a nearer approach to the proper point. After Augustus had supplanted his rivals, he parcelled certain lands in Italy among his veteran soldiers; and to the classical reader it is well known that, upon this occasion, Virgil was deprived of his little patrimony. The example was followed by other emperors. Alexander Severus allotted to officers and soldiers various lands which had been acquired on the frontiers, and which were to descend to their heirs on the condition of performing military service. This was a plan for securing a permanent guard in the outposts of the empire; and, as Taurellus and Gothofredus have remarked, it bears some resemblance to the feudal system;[7] but Hotman has very clearly pointed out the distinction between these military retainers and the feudal vassals.[8]

Sir Thomas Craig has not overlooked the strong resemblance between the feudal tenures and the Turkish timars.[9] "The Spahyes," says Dr Thomas Smith, "are another great support of the Turkish empire; soldiers who are obliged to serve on horseback by the tenure of the lands (*timars*) and estates they are possest of; these being not only the reward of their sweat and blood, but ties and obligations to further service in the field upon the first summons; each bringing so many horses with him according to the value of what he holds, which is the reason they do not receive an asper of pay out of the Grand Signior's exchequer, and are therefore known by the name of Timar-Spahyes, or *Feudatory*, to distinguish then from other Spahyes who live in the cities, and have not obtained a piece of land."[10] A more recent author represents this military establishment as still unchanged. "These," says Dr Walsh, "are a kind of feudal cavalry, possessing hereditary lands, on the tenure of appearing in the field when called on. If they have no male children, the lands devolve to the commander, who assigns them to others on the same terms, and so the corps is kept up. It consists of sixteen legions; who are perhaps the best mountain horsemen in the world."[11] Major Denham discovered traces of the same system at Bornou in the interior of Africa. "The feudal law," as he informs us, "exists here in full force; and a man unwilling to serve, provides one or more substitutes, according to his means."[12] Here however we have but an inadequate representation of the feudal system. In the centre of India, this system is to be found in a more complicated and perfect form. Of its present character and condition in Rajasthan, some very curious and interesting details have been furnished by Lieut. Col. Tod, who supposes Asia to have been the cradle of feudalism. "The perfection of the system in England," he remarks, "is due to the Normans, who brought it from Scandinavia, whither it was probably conveyed by Odin and the Sacasenæ, or by anterior migrations,

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[1] "They are at present," says Dr Smollett, "as free and independent of their chiefs as the law can make them; but the original attachment still remains, and is founded on something prior to the feudal system, about which the writers of this age have made such a pother, as if it was a new discovery, like the Copernican system. Every peculiarity of policy, custom, and even temperament, is affectedly traced to this origin, as if the feudal constitution had not been common to almost all the nations of Europe. For my part, I expect to see the use of trunk-hose and buttered ale ascribed to the influence of the feudal system." (Miscellaneous Works; vol. vi. p. 275.)

[2] With respect to the state of vassalage in those two countries, consult Mr Coxe's Travels into Poland, Russia, Sweden, and Denmark, vol. i. p. 118. 137. vol. ii. p. 93. 110. Lond. 1784, 2 vols. 4to.

[3] Hallam's View of the State of Europe during the Middle Ages, vol. i. p. 200. sec. edit. Lond. 1819, 3 vols. 8vo.

[4] Macieiowski Historia Juris Romani, p. 36. edit. sec. Varsaviæ, 1825, 8vo. "Antiquitus non videntur pertinuisse ad *populum* nisi patricii, moribus Etruscorum id ita serentibus; apud quos minime totus populus libertate gavisus est, sed jus, quod dicitur feudale, ibi valuit."

[5] Budæi Annotationes in Pandectas, p. 359. edit. Paris. 1535, fol.

[6] Connani Commentariorum Juris Civilis tom. i. f. 119. Paris. 1553, 2 tom. fol.—See Cæsar de Bello Gallico, lib. iii. cap. xxii. and Gebaveri Vestigia Juris Germanici antiquissima in C. Cornelii Taciti Germania obvia, p. 148. Gottingæ, 1766, 8vo.

[7] Taurelli de Militiis ex casu, ad Ant. Augustinum Epistola, p. 83. Gothofredus ad Cod. Theodos. lib. vii. tit. xv. p. 305. "Quæ pleraque ad feudorum naturam proxime accedunt," says this most able commentator. Haloander supposes feuds to be mentioned in the Novels under the name of *militiæ*. "Animus erat in finem adjicere Feudorum Consuetudines, quas veteres appellare solebant jura militiarum, et Imp. nominat στρατειας." See his dedication prefixed to *Novellarum Constitutionum Dn. Justiniani Principis, quæ exstant, et ut exstant, Volumen.*" Norembergæ, 1531, fol. This opinion has however been refuted by different writers. "Militiæ enim," says Contius, "fuerunt officia certa ministris magistratuum assignata, quæ pecunia vendi poterant, et ideo in commercio erant, ut fuit officium apparitorum. Apparet ergo multum differre militiam a feudo. Nam militia est jus personæ; feudum in rebus immobilibus et quasi in possessione consistit." (Fornerii et Contii Tractatus de Feudis, p. 84. Leovardiæ, 1694, 8vo.)

[8] Hotomani Disputatio de Feudis, p. 10. Lugduni, 1573, fol.

[9] Cragii Jus Feudale, p. 27. edit. Baillie. Edinb. 1732, fol.

[10] Smith's Remarks upon the Manners, Religion, and Government of the Turks, p. 133. Lond. 1678, 8vo.

[11] Walsh's Narrative of a Journey from Constantinople to England, p. 186. Lond. 1828, 8vo.

[12] Denham's Narrative of Travels and Discoveries in Northern and Central Africa, p. 150. Lond. 1826, 4to.

from Asia; which would coincide with Richardson's hypothesis, who contends that it was introduced from Tartary. Although speculative reasoning forms no part of my plan, yet when I observe analogy on the subject in the customs of the ancient German tribes, the Franks, or Gothic races, I shall venture to note them. Of one thing there is no doubt—knowledge must have accompanied the tide of migration from the east: and from higher Asia emerged the Asi, the Catti, and the Cimbric Lombard, who spread the system in Scandinavia, Friesland, and Italy."[1] Nor was this system confined to the continental part of Asia: Molina informs us that it prevailed to a great extent in the island of Japan.[2] That the germ of the feudal system first appeared in Asia, is at least highly probable. Its earliest traces have been discovered among the Gothic tribes of Europe. Successive swarms of Goths moved towards the north-western parts of the old world; and when they had subdued many different nations, it may be presumed that they settled the conquered provinces according to some general plan which they had learned in the east. Of the Asiatic tribes it is one great characteristic to adhere, from one century to another, to the customs of their ancestors. This remark is signally verified in the history of the Chinese and Hindus; and it seems applicable to all the other tribes of men who inhabit that quarter of the globe.

Of the early progress of the feudal system, so able a delineation has been given by Dr Stuart, that we are here tempted to introduce a long extract from his work. Having quoted a passage from Tacitus,[3] he proceeds with the subsequent commentary. "This passage abounds in instruction the most important. It informs us that the German had no private property in land, and that it was his tribe which allowed him annually for his support a proportion of territory; that the property of the land was invested in the tribe, and that the lands dealt out to individuals returned to the public, after they had reaped the fruits of them; that, to be entitled to a partition of land from his nation was the distinction of a citizen; and that, in consequence of this partition, he became bound to attend to its defence, and to its glory. With these ideas, and with this practice, the Germans made conquests. In conformity therefore with their ancient manners, when a settlement was made in a province of the empire, the property of the land belonged to the victorious nation, and the brave laid claim to their possessions. A tract of ground was marked out for the sovereign; and, to the inferior orders of men, divisions corresponding to their importance were allotted. But while, in their original seats, such partitions were annual, it was expedient that they should now be invested in the possessor. A more enlarged idea of property had been gradually unfolding itself; and though it was convenient to, and suited the views of a narrow community, to take back its land, the measure was not practicable in an extensive society. Nations were no longer to shift their habitations. The boundaries of particular states were to be respected. The tribe ceasing to wander, the individual was also to be stationary. The lot or partition now received by him, was to continue in his possession, and to be an object of his industry. He was to take root, if I may so speak, in a particular spot. He was to bestow on it his affection; it was to feed and to enrich him with its produce. His family was to feel an interest in his estate; his sons were to succeed him. Heirs were to fail in the blood of the proprietor. It affected him, that the crown or a stranger should possess the subject of his toils and attentions. The powers of sale and donation came to be understood. The right of holding a landed territory with no limitation, and of disposing of it at pleasure, was known and prevailed.... When we mount up to the origin of customs, we are to be struck with their simplicity. The lot or partition to the sovereign was to constitute his domains. It was to support his splendour, to defray the expenses of government, and to maintain his household. The lot or partition to the individual was to give rise to allodiality. It was the land which was free, in contradistinction to tenure; and, being still the mark of a citizen, it subjected him as in Germany, to the general obligation of taking arms in defence of the community.[4] But the domains of the sovereign, and the lands of lot or partition to the people, could not exhaust all the territory of a conquest. They were principal and natural objects of attention; yet, after their appointment, there were much extensive property, and many fair possessions. The ancient maxims of the people did not allow them to seize these by a precarious occupation. Men who had connected the property of land with the tribe, and not with the individual, could not conceive any title in consequence of which they might arrogate possessions to humour their fancy, or to flatter their pride. Their ancient notions continued their operation: the community was concerned with what no man could claim. The lands accordingly which were assigned neither to the sovereign nor to the people, which formed not the domains of the former, nor the partitions of the latter, were the lands of the state or the fisc."[5]

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[1] Tod's Annals and Antiquities of Rajast'han, or the Central and Western Rajpoot States of India, vol. i. p. 132. Lond. 1829–32, 2 vols. 4to.

[2] "Illud obiter dixerim, apud Japonenses nil videri esse frequentius quam feuda. Cum enim bellis perpetuo in ea ingenti insula principes inter se contendant, antiquo inter eos more, quæ unusquisque bello obtinet, continuo dividit inter suos duces, et alios quos diligit, cum onere sibi serviendi in bello, et alia onera præstandi; mutatque dominos de uno loco in alium, auferendo ab eis quæ possidebant, et alia eis largiendo. Majores autem dinastæ sub supremo aliquo principe ita constituti, divisa habent loca, quibus dominantur, in alios sibi inferiores, cum eisdem oneribus sibi inserviendi in bello et præstandi alia realia onera, et illi in alios, quousque devenitur ad infimos *tonos*, quos ipsi vocant, qui similiter dominantur unusquisque in suo oppido, et simili fere lege, ut vassalli ipsum comitentur in bellum, et servitia alia realia præstent. Mores tamen et usus feudorum non iidem, sed diversi in aliquibus sunt apud ipsos ab iis qui in Germania, Gallia, et Italia vigent." (Molina de Justitia et Jure, tom. ii. col. 1062. edit. Mogunt. 1659, 6 tom. fol.)

[3] Tacitus de Moribus Germanorum, cap. xxvi.

[4] "The allodial lands," as Dr Stuart remarks, "were enjoyed in full property, and are therefore opposed to feudal or beneficiary possessions, which were received with limitations, and under the burden of military service to the grantors." The word *al-od* is supposed to be equivalent to *all-hood*, and therefore to indicate completeness of possession. It is synonymous with *udal*, which is employed to denote the right of such lands in Orkney and Zetland; "whereby," as Lord Stair has stated, "without any infeftment, investiture, or other right or writ, they enjoy lands and hereditaments." (Institutions of the Law of Scotland, b. ii. tit. ii. § 11.) See likewise Lord Bankton's Institute of the Laws of Scotland, vol. i. p. 541. This word is evidently borrowed from the ancient Norwegian language. In the Islandic language, *ódal* signifies allodial property, but it also signifies *res derelicta*. (Haldorsonii Lexicon Islandicum, vol. ii. p. 121.) It is not therefore improbable that the term was originally applied to lands which, having been found deserted, were occupied without form or ceremony.

[5] Stuart's View of Society in Europe, p. 24.—It is not the object of this article to attempt a developement of the feudal system, but merely a faint outline of the history of the feudal law. Besides the different works which we here have occasion to quote, particularly those of Stuart and Hallam, we may refer the English reader to Dr Robertson's View of Society in Europe, prefixed to his History of Charles V.

Feudal Law.

Du Moulin has traced the origin of the feudal law to the Franks, by whom he supposes it to have been introduced into Gaul.[1] Grotius and other writers have, with greater probability, represented it as having been widely diffused at an early period.[2] Lombardy has frequently been regarded as the place of its origin, because to that country we are indebted for the ancient digest of this consuetudinary law.[3] The *Feudorum Consuetudines* are said to have been compiled by Gerardus Niger, who is likewise called Capagistus, and by Obertus de Orto or Horto, who were both lawyers and consuls of Milan.[4] They lived in the reign of Frederick the First, surnamed Barbarossa, which commenced in 1152, and terminated in 1190. Whatever share they might have in preparing the materials, it may perhaps be suspected that they did not digest the work in its present form. Their opinions are on some occasions placed in opposition to each other, and are quoted as if from distinct works. Thus in lib. ii. tit. li. § 3. "Similiter si quis investitus fuerit de feudo, ita ut ad fœminas transiret, et duas filias tantum reliquerit, quarum una filium habeat, et altera filiam; utrum post mortem illarum masculus tantum feudum habere debeat? Secundum Gerardum, masculus tantum: Obertus contra." And in § 6 of the same title: "Similiter feudum lege commissoria datum non valet, id est, si ad certum tempus pecunia non solvatur creditori, ut habeat in feudum. Gerardus. Et secundum Obertum, valet." On other occasions, both names are subjoined: "Gerardus et Obertus." It might indeed be conjectured that the work was arranged by their joint labour; and that when any difference of opinion occurred, they took care to state it in this formal manner. Du Moulin supposes Obertus to have been the sole compiler. We are assured by Odofredus, a commentator on the Code, who lived about the year 1250, that Hugolinus, otherwise called Hugo a Porta Ravennate, who died in the year 1168, added the feudal law to the ninth collation of the Novels, and that it was received as a tenth collation.[5] Some writers consider the statement as a mere device, intended to enhance the authority of this branch of jurisprudence. The feudal law is commonly subjoined to the *Corpus Juris Civilis*, of which many of the older civilians regarded it as a component part. "The last tome of the civile law," says Sir Thomas Ridley, "is the Feudes, that is, the books of customes and services that the subject or vassall doth to his prince or lord, for such lands or fees as he holdeth of him."[6] In the common editions, the *Feudorum Consuetudines* are divided into two books; but the edition of Cujacius, Coloniæ, 1588, 8vo, exhibits a new arrangement, with a series of five books. The first book he ascribes to Gerardus, the second and third to Obertus; the fourth is taken from several ancient authors, and the fifth consists of imperial constitutions relative to matters of feudal cognizance. To the common editions in two books, are likewise appended constitutions of several emperors; and two of them, issued by Henry the Seventh, are described by the term *Extravagantes;* a term which is also used in the canon law, to denote documents which wander beyond the limits of a particular collection.[7] The work itself is partly composed of such constitutions; and the entire collection closes with an instrument relative to the peace of Constance, *De Pace Constantiæ*, concluded, on the one part, between the emperor Frederick the First, his son Henry king of the Romans, and certain nobles of Germany, and, on the other, various cities of Lombardy, the march of Ancona, and Romagna.

These books of the feudal law are evidently written by individuals familiar with the doctrines and the phraseology of the civil law; and the new system of jurisprudence may be considered as a scion from the old. The composition necessarily partakes of the general barbarism of the age to which it belongs, nor are the materials reduced to a systematic or lucid form.[8] Some of the more classical civilians have therefore treated this law of Lombardy with the utmost contempt.[9] As to the authority which properly belongs to it, the feudalists have entered into much discussion, and have maintained various opinions. Some of the early writers represent it as having been sanctioned by different emperors, particularly by the first three Fredericks, but others consider this sanction as more than doubtful. Craig is induced to suppose that the feudal law must have derived its authority from some imperial rescripts, although they have not descended to our time; for he cannot conceive that the emperors would otherwise have permitted it to be taught in the schools, and observed in the judicatories. Du Moulin, on the other hand, considers the private part of the compilation as unwritten law, "jus non scriptum," adopted at Milan, and the remainder, the constitutions interspersed, as written law, "jus scriptum," retaining its force within the limits of the empire.[10] This appears to be a very sound opinion; nor do we think it necessary to mention the various suggestions and speculations of other writers. In many different countries, this compilation has been received and partly adopted as consuetudinary law, and in all those countries has been modi-

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[1] Molinæi Commentarii in Parisienses Consuetudines, p. 10. edit. Genev. 1613, fol.—The same opinion is adopted by many other writers, and, among the rest, by Hervé in his Théorie des Matieres Féodales et Censuelles, tom. i. p. 2.

[2] Grotius de Jure Belli ac Pacis, lib. ii. cap. vii. § 21. See the same illustrious writer's Historia Gotthorum, Vandalorum, et Langobardorum, prol. p. 64. Amst. 1655, 8vo.

[3] Panciroli Thesaurus variarum Lectionum utriusque Juris, p. 130. Venetiis, 1611, fol. Giphanii Antinomiæ Juris Feudalis, p. 29. Francofurti, 1606, 4to. "Manet igitur verum," says Giphanius, "feuda, quoad originem, ad clientelas Romanorum, vel ad homines Romanorum referre posse. Deinde, feuda sunt ex jure Longobardorum, non si spectemus originem, sed si respiciamus ad rerum distinctiones, ordinationes, constitutiones, statuta, quæ ex moribus et quotidiana observatione Longobardorum fluxerunt."

[4] Dieck's Literärgeschichte des Longobardischen Lehenrechts. Halle, 1828, 8vo. Laspeyres ueber die Entstehung und älteste Bearbeitung der Libri Feudorum. Berlin, 1830, 8vo.

[5] B. G. Struvii Historia Juris, p. 721. Jenæ, 1718, 4to.

[6] Ridley's View of the Civile and Ecclesiasticall Law, p. 68. sec. edit. Oxford, 1634, 4to.

[7] See F. A. Biener's Geschichte der Novellen Justinian's, S. 277. Berlin, 1824, 8vo.

[8] "Stilus forensis est, qualis jurisconsultorum ejus temporis esse potuit: scripti enim sunt seculo inerudito, neque fieri potuit quin aliquod ejus seculi vitium contraxerint. Verba ipsa Latina, nisi si quæ sint fori propria. Phrasis, sive, ut grammatici loquuntur, constructio Longobardica est, ut facile quivis sine interprete sensum percipere potest. Tumultuarie sane sunt conscripti, ex adversariis sive schedis Gerardi et Oberti relictis, ab alio puto quam ipsis collectis. Obertus enim et Gerardus, prout quæque facti species occurrerat, consulti quid de eo sentirent, scripto declararunt. Hæc eorum adversaria, post eorum excessum, aliquis juris feudorum studiosus in libros redegit, sine delectu, sine methodo, quod non est negandum: ita tamen eorum responsa celebrata sunt, et in honore habita, ut pro jure certissimo a posteris adhuc sint usurpata." (Cragii Jus Feudale, p. 36.)

[9] "Feuda postremo," says Taurellus, "quæ non minus barbaro quam inepto, et sibi parum constanti, ac vix meo judicio legi digno volumine continentur." (De Militiis ex casu, ad Ant. Augustinum Epistola, p. 81.) See likewise Gravinæ Origines Juris Civilis, p. 103. edit. Mascovii.

[10] Molinæi Commentarii in Parisienses Consuetudines, p. 24.—See likewise Duck de Usu et Authoritate Juris Civilis, f. 35. b. Bitschii Commentarius in Consuetudines Feudorum, p. 14. G. A. Struvii Syntagma Juris Feudalis, p. 30.

fied by tacit usage, or by express enactments, nor has it any other authority except such as it has thus obtained. The Lombardic body of law is described as "Feudorum Consuetudines," and "Jus Feudale commune;" the first title denoting that it is consuetudinary or unwritten law, and the second, that it has obtained more or less authority wherever the feudal law has been adopted.

The substance of these books was digested into a new form by Antonius Minuccius a Prato Veteri, a professor in the university of Bologna, who was born about the year 1380;[1] and his labours are said to have received the sanction of the emperor Sigismund, as they certainly did that of Frederick the Third.[2] Haloander had originally intended to subjoin it to his edition of the Novels; but it was not till after a long interval that the work was first published by Schilter. Another digest of the same materials was afterwards undertaken by Bartholomæus Baraterius or de Barateriis, who was a native of Piacenza, and was successively a professor at Pavia and Ferrara. Having completed his work in 1442, he dedicated it to the duke of Milan. It was first printed at Paris in the year 1612.[3] Neither of these works seems to have obtained any permanent footing, even in the universities of Italy. The books of the feudal law were exhibited in a German dress by Dr Lorenz Weidmann, who likewise introduced some changes of arrangement. His work, *Die Lehenrecht verdeutscht*, was printed by Schoiffer of Mainz in the year 1530.

The principles of the feudal law had soon begun to be taught in the universities. The text was illustrated by many glosses and commentaries; and many summaries and treatises have from time to time been added. The principal feudalists who preceded his own time, are thus enumerated by Dr Duck: "Horum librorum authoritatem augent egregii illi jurisconsulti qui ad eos glossas, commentarios, et tractatus scripserint. Glossas in Feuda scripserunt Bulgarus, Pyleus, Ugolinus, Vicentius, Jac. Goffredus, aliique; sed Jac. Columbinus eorum ultimus omnes superavit, et post eum, ait Jason, nemo glossas in Feuda scribere tentavit.[4] Alii summas et tractatus de Feudis composuerunt, Odofredus, Jac. de Arena, Hostiensis, Jac. Ardizoni, Zasius, Rebuffus, Hannetonius, Henr. Rosenthall, aliique, qui omnem Feudorum scientiam amplissime tradiderunt. Commentarios in Feuda scripserunt Jac. de Belvisio, Andr. de Iserma, Baldus, Jac. Alvarottus, Math. de Afflictis, Fr. Curtius, Jac. Cujacius, aliique, in quibus eminet Cujacii elegantia et literarum splendor, authoritas et judicium Jac. de Belvisio et Baldi, quorum ille octies se legisse libros Feudorum Papiæ testatur, Baldus vero commentarios suos scripsit postquam jus civile per quadraginta septem annos professus insignem famam acquisiverat. Et inter hos omnes e glossographis Jacobo Columbino, e summistis Jacobo Ardizoni, e commentariis Jacobo de Belvisio primus locus ab omnibus conceditur."[5] To this enumeration some names ought perhaps to have been added, particularly those of Hotman and Vulteius. Of the more recent commentaries on the text, the most copious is that of Caspar Bitsch, professor of law in the university of Strasburg.[6] Among the systematic treatises which have appeared since the publication of Duck's very useful work, it may be proper to mention the elder Struve's *Syntagma Juris Feudalis*, which contains much information in a form not very elegant or attractive.[7] Many elementary works, such as those of Schilter, Stryk, and G. L. Böhmer, and an immense number of detached dissertations, have from time to time been published in Germany, where every province of jurisprudence is most laboriously cultivated. Of separate tracts on the feudal law, an ample collection was published in Jenichen.[8] Various writers treat of this law as it has been adopted and modified in different countries. Thus the feudal law, as applied in Scotland, has been illustrated with much learning and ability by Sir Thomas Craig, one of the greatest lawyers whom his country has produced. One of the earliest books on the law of England is Thomas Littleton's treatise on tenures; and the feudal law of that country was afterwards discussed by Sir Henry Spelman, Sir Martin Wright, Sir Jeffrey Gilbert, and various other writers.

In France the feudal law was embodied in the *loi coutumier* of different provinces; and many curious reliques of jurisprudence have thus been preserved. The most interesting of these are perhaps the *Coustumes de Beauvoisis*, digested by Philippes de Beaumanoir.[9] Montesquieu has described it as an admirable work,[10] and has quoted it upon many different occasions. "This treatise of Beaumanoir," says Mr Barrington, "is so systematical and complete, and throws so much light upon our ancient common law, that it cannot be too much recommended to the perusal of the English antiquary, historian, or lawyer. He kept the courts of the Comte de Clermont, and gives an account of the customary laws of Beauvoisis (which is a district about forty miles to the northward of Paris) as they prevailed in the year 1283. He is consequently a more ancient writer than Littleton, and, to speak with all due reverence of this father of our law, perhaps a better writer. It need hardly be said that the customs of

[1] Pancirolus de claris Legum Interpretibus, p. 198. Savigny's Geschichte des Römischen Rechts, Bd. vi. S. 255. Osservazioni e Dissertazioni varie sopra il Diritto Feudale, concernenti l'Istoria e le Opinioni di Antonio da Pratovecchio, celebre Giureconsulto del Secolo xv. e Riformatore dei Libri de' Feudi. Livorno, 1764, 4to. This elaborate volume, which appeared without the name of the author, was written by Migliorotto Maccioni, a professor in the university of Pisa.

[2] Laspeyres über die Entstehung und älteste Bearbeitung der Libri Feudorum, S. 126. Berlin, 1830, 8vo. This is a work of much critical research, and the author, who is now a professor in the university of Halle, belongs to the school of Savigny.

[3] The works of Minuccius and Baraterius are subjoined to Schilter's Codex Juris Feudalis Alemannici. Argentorati, 1695, 4to.

[4] See Savigny's Geschichte des Römischen Rechts im Mittelalter, Bd. v. S. 82. Heidelberg, 1815–31, 6 Bde. 8vo.

[5] Duck de Usu et Authoritate Juris Civilis, f. 38. edit. Lond. 1653, 8vo. A similar account is given by Pancirolus, Thesaurus variarum Lectionum utriusque Juris, p. 131. Venetiis, 1611, fol. See likewise Rittershusii Partitiones Juris Feudalis, p. 15. edit. Argentorat. 1659, 8vo.

[6] Caspari Bitschii Commentarius in Consuetudines Feudorum. Argentorati, 1673, 4to.

[7] Geo. Ad. Struvii Syntagma Juris Feudalis. Francofurti ad Moenum, 1703, 4to. This is the eighth edition.

[8] Thesaurus Juris Feudalis, continens optuma atque selectissima Opuscula, quibus Jus Feudale explicatur. Francof. ad Moen. 1750–4, 3 tom. 4to.

[9] Coustumes de Beauvoisis, par Messire Philippes de Beaumanoir, Bailly de Clermont en Beauvoisis, Assises et bons Usages du Royaume de Jerusalem, par Messire Jean d'Ibelin, Comte de Japhe et d'Ascalon, S. de Rames et de Baruth, et autres anciennes Coutumes; le tout tiré des manuscrits, avec des notes et observations, et un glossaire pour l'intelligence des termes de nos anciens auteurs, par Gaspard Thaumas de la Thaumassiere, Ecuyer, S. de Puy-ferrand, Bailly du Marquisat de Château-neuf-sur-Cher, Avocat en Parlement. Bourges, 1690, fol.—Of the *Assises de Jerusalem*, a new and complete edition, in three volumes quarto, was in 1830 announced by Cotta of Stuttgard. The editors are E. H. Kausler and J. C. Bluntschli, who promise a very careful revisal of the text, with copious and various illustrations; and, for the satisfaction of many readers, we may add that they write, not in German, but in Latin. Of the second part, the *Assise de la Court des Borgés*, the original has not yet been printed. Some extracts, relative to maritime law, may be found in Pardessus, *Collection de Lois Maritimes antérieures au XVIIIe Siècle*, tom. i. p. 275. Paris, 1828, 4to.

[10] Montesquieu de l'Esprit des Lois, liv. xxvi. chap. xv.

the two countries were at this time very similar, especially of the more northern parts of France: if we wanted other proof, the commentators on the oldest French law books cite Littleton as illustrating their customs."[1] Of the customary laws of France the other collections are very numerous.[2] Nor must we here neglect to particularize a very curious relique of early jurisprudence, the *Assises de Jerusalem*, which are decidedly of a French origin. After the conquest of the holy city in the year 1099, the barons who led the crusade elected Godefroy de Bouillon king of Jerusalem; and it was one of the new sovereign's first cares to form a body of laws for the government of his subjects. By the counsel of the patriarch, and of his princes and barons, " et des plus sages homes qu'il pooit avoir," he appointed wise men to make enquiry at persons from different countries as to the particular usages of those countries. Having received the desired information in writing, he again assembled his principal adherents; and having laid this document before them, and caused it to be read, he afterwards, with their counsel and concurrence, selected what to him seemed good, " et en fit assises et usages que l'on deust tenir et maintenir, et user au royaume de Jerusalem, par lesquels il, ses gens, et son peuble, et toutes autres manieres des gens alans, et venans, et demorans, fussent governés et menés à droit et à raison el dit royaume." They were called *Assises* from the circumstance of their having thus been confirmed in an assembly of the chief persons of the state. They were afterwards modified and enlarged by this king and his successors; and about the year 1250 were arranged by Jean d'Ibelin, Comte de Japhe et d'Ascalon, Seigneur de Rames et de Baruth. Having been adopted in the kingdom of Cyprus, they were revised in the year 1369 by sixteen individuals nominated in an assembly of the estates of that kingdom. They had been translated into Greek for the benefit of those subjects who did not understand the original language; and of this version some portions have been preserved in the Royal Library at Paris. After Cyprus had fallen under the dominion of the Venetians,[3] the book was translated into the Italian language.[4] It is generally admitted that the laws thus adopted in the kingdoms of Jerusalem and Cyprus, were in a great measure derived from the customs and usages of the kingdom of France.

The feudal system seems to have arrived at maturity during the reign and in the dominions of Charlemagne and his immediate successors. The reliques of their legislation are to be found in the *Capitularia Regum Francorum*, of which we have given a separate account. As the empire of Charlemagne not only included France and Germany, but likewise a great portion of Italy, and some portion of Spain, a certain uniformity of laws and usages was naturally promoted by this political union. " Feudal tenures," it is stated by Mr Hallam, " were so general in the kingdom of Aragon, that I reckon it among the monarchies which were founded upon that basis. Charlemagne's empire, it must be remembered, extended as far as the Ebro. But in Castille and Portugal they were very rare, and certainly could produce no political effect. Benefices for life were sometimes granted in the kingdoms of Denmark[5] and Bohemia. Neither of these, however, nor Sweden,[6] nor Hungary, comes under the description of countries influenced by the feudal system. That system, however, after all these limitations, was so extensively diffused, that it might produce confusion, as well as prolixity, to pursue the collateral branches of its history in all the countries where it prevailed."[7] The prevalence of the feudal law in Lombardy has already been mentioned; and it sooner or later extended its influence to almost every corner of Italy, including the islands as well as the continental states.[8] In England and Scotland it struck a very deep and vigorous root. Its progress in the former country seems to be correctly stated by Blackstone. " This feudal polity," he remarks, " which was thus by degrees established over all the continent of Europe, seems not to have been received in this part of our island, at least not universally, and as a part of the national constitution, till the reign of William the Norman. Not but that it is reasonable to believe, from abundant traces in our history and laws, that even in the times of the Saxons, who were a swarm from what Sir William Temple calls the same northern hive, something similar to this was in use; yet not so exclusively, nor attended with all the rigour that was afterwards imported by the Normans. For the Saxons were firmly settled in this island, at least as early as the year 600; and it was not till two centuries after, that feuds arrived to their full vigour and maturity, even on the continent of Europe."[9] Craig supposes the feudal law to have been established in Scotland before it was established in England;[10] but this is an opinion which apparently must continue to rest on conjecture, and not on historical evidence. (D. I.)

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1 Barrington's Observations on the more ancient Statutes, p. 439.

2 See Dupin's edition of Camus's Lettres sur la Profession d'Avocat, tom. ii. p. 190.

3 See Johann Paul Reinhards vollständige Geschichte des Königreichs Cypern. Erlangen und Leipzig, 1766–8, 2 Bde. 4to.

4 Le Assise et bone Vsanze del Reame de Hyervsalem. Venetia, 1535, fol. The volume concludes with the following colophon: " A laude & honor del Omnipotente Iddio, finisce il presente libro, qual è de le Assise & bone Vsanze del Reame de Hierusalem, stampato in Venetia, regnante l'inclito Meser Andrea Gritti, Doxe di Venetia, nelli anni de la Natiuita del Signor nostro MDXXXV. del mese di Marzo, in la stamparia di Aurelio Pincio Venetiano." The name of the translator is Florio Bustron. This translation contains both the laws which relate to *L'alta Corte* and those which relate to *La Corte de li Borgesi*. Both parts may be found in the collection of Canciani, *Barbarorum Leges antiquæ*, vol. ii. p. 479. vol. v. p. 107. Venetiis. 1781–92, 5 tom. fol.

5 See Dansk Lehns Ret af Peder Kofod Ancher. Kiöbenhavn, 1777, 8vo.

6 Stiernhöök de Jure Sueonum et Gothorum vetusto, p. 276. Holmiæ, 1682, 4to.

7 Hallam's View of the Middle Ages, vol. i. p. 201.

8 The Sicilians, says Mr Brydone, " still boast that they retain more of the feudal government than any nation in Europe. The shadow indeed remains, but the substance is gone long ago." (Tour through Sicily and Malta, vol. ii. p. 225. Lond. 1773, 2 vols. 8vo.)

9 Blackstone's Commentaries on the Laws of England, vol. ii. p. 48. See likewise Dr Sullivan's Historical Treatise on the Feudal Law, and the Constitution and Laws of England, p. 18. Lond. 1772, 4to.

10 Cragii Jus Feudale, p. 47. Brussii Principia Juris Feudalis, p. 5. Edinb. 1713, 8vo. See Dr Stuart's Observations concerning the Public Law and the Constitutional History of Scotland, p. 7. Edinb. 1779, 8vo. Lord Kames, whose speculations often rest upon a very insecure foundation, is pleased to express himself in the following terms: " I entertain some doubts whether the feudal law was introduced into Scotland so early as in the reign of Malcolm II. What to me brought this thing first under suspicion, is a fact that can be made extremely evident. When one dives into the antiquities of Scotland and England, it will appear that we borrowed all our laws and customs from the English. No sooner is a statute enacted in England, but, upon the first opportunity, it is introduced into Scotland; so that our oldest statutes are mere copies of theirs. Let the Magna Charta be put into the hands of any Scotsman, without giving its history, and he will have no doubt that he is reading a collection of Scots statutes or regulations. Now it is a point settled among the best English antiquaries, that the feudal law was introduced into England by William the Conqueror. I need not spend time upon this topick, after what is said by the accurate Spelman, and by our countryman Craig. Joining these two things together, a strong presumption arises, that the feudal law made its progress from England to this country, as all the English statutes, making improvements and alterations upon it, certainly did. But this presumption receives additional force,

FEVER is the term applied to a class of diseases characterized generally by increased heat of surface, frequency of pulse, and disturbance of the various functions. All fevers, whatever be their nature, usually commence with general feelings of illness, such as restlessness, irritability, languor, pain in the back and all the joints, sensations of coldness, even though the body may feel hotter than usual, generally terminating in shivering more or less severe; the features assume a peculiar and shrunken appearance, and the eye is muddy and more or less injected. This *cold* stage is usually followed by a hot one, when the skin has a dry burning sensation, with hot dry tongue, increased pulse, &c.; and this stage again terminates in a more or less copious sweating, which forms the third stage of the disease. These three stages may be passed through in one day, after which the person may be restored to health. The malady is then termed a "weed" or ephemeral fever. On the other hand, these three stages may recur day after day at stated intervals, when the disease is styled an intermittent fever. The malady, however, may continue many days without being marked by the occurrence of remissions or intermissions, when it is termed a continued fever. When this last form is attended with marked eruptions or rashes on the skin, the disease receives the name of an eruptive fever. Fevers are hence conveniently divided into three distinct classes. 1. Continued fevers, as typhus; 2. Periodic fevers, as ague and yellow fever; 3. Eruptive fevers, as smallpox, measles, and scarlet fever.

Of all classes of disease fevers are the most common, and not only attend in one or other of their forms almost every derangement and injury of the human body, but by their mortality they constitute one of the chief outlets of life. When they rage as endemics or epidemics they are among the most severe and fatal of diseases. In intertropical regions, after the subsidence of the rains, when the almost vertical sun causes the malarious exhalations to arise in prodigious quantities, all the low-lying districts become so unhealthy that no white man exposed to their influence escapes fever in one form or other, and even the black races suffer severely.

All fevers when they appear as epidemics seem to have certain features in common, whether they belong to the class of continued, periodic, or eruptive fevers. Thus the virulence of all is increased by the want of cleanliness and of ventilation in the dwelling, by the overcrowding in a confined space or dwelling, by the want of personal cleanliness, by the use of indigestible or unwholesome food, by residence in a damp low-lying locality, or where exhalations from damp ground, from putrescent heaps, from marshes, drains, or ditches abound. Hence the prevalence of fevers in all marshy districts; hence the mortality from fevers in armies when kept long encamped on the same spot of ground; hence the ravages of fever among our overcrowded and under-fed lower classes, and among the Irish in the late fever epidemics. A certain elevation of temperature, combined with the miasmatous exhalations from damp grounds, appears to be necessary to the existence of certain forms of fever. Thus yellow fever north of the equator only breaks out after the heavy rains of July and August, when the ground, saturated with the heavy rains, begins to throw off copious exhalations under the influence of the almost vertical sun. It scarcely ever appears where the mean temperature of the months during which it breaks out is below 70° Fahr., or where the ground is 2500 feet above the level of the sea; hence it chiefly appears only during the months of September and October. South of the line, the corresponding period when this deadly fever prevails is March and April; and at these periods all low marshy coasts ought to be avoided by whites, as this disease falls with especial severity on them. In more temperate climes, or during the other months of the year in intertropical regions, intermittent fevers (or agues) of more or less severe type, seem to take the place of yellow fever; while typhus fever is the peculiar epidemic of crowded towns and of localities ill-ventilated, ill-drained, or exposed to the miasmata arising from decomposing animal or vegetable matter, in the more temperate regions of the earth.

Much may be done by draining and ventilation for the prevention of fever; and many instances are recorded where both typhus and yellow fever have been almost quite extirpated by improved drainage and ventilation. A large tenement in Glasgow, formerly notorious as a nest for typhus, is an instance of the first, and New York and several towns in North America are instances of the other.

As fevers form the especial scourge of adult life, the means of preventing these attacks merit much attention; and were sanitary measures more rigidly enforced in all our towns it cannot be doubted that the misery, destitution, suffering, and orphanage which prevail so much among the lower classes would be greatly diminished.

FEVRE, Tannegui Le, a distinguished French scholar, was born at Caen in Normandy in 1615. The numerous difficulties which opposed his early education he overcame by his own diligence and ability, and was at length enabled to enter the Jesuit College of La Flèche, where he greatly distinguished himself. Refusing to take orders in the Romish Church, he left Normandy for Paris, where he was appointed by Richelieu inspector of the press of the Louvre. After the Cardinal's death he retired to Langres and finally to Preuilly, where he openly professed the doctrines of the Reformed faith. He was immediately offered a chair in the Academy of Saumur, which he shortly afterwards exchanged for a more eligible appointment in Heidelberg. In this latter city he died Sept. 12, 1672. Le Fèvre is perhaps fully better known as the father of Mme. Dacier than from the merits of his editions of some of the classics.

The following list contains the most important of these works:—Editions of several works of Lucian; Longinus's *Treatise on the Sublime*; the Fables of Phædrus; Lucretius; the *Histories* of Ælian; Eutropius, Justin, Terence, and Horace; the *Library* of Apollodorus; Virgil; the *Panegyric of Trajan* by Pliny the younger; Dionysius of Alexandria, Anacreon, and Sappho; French translations of the *Festinus* of Xenophon, the *First Alcibiades* of Plato, the *Treatise on Superstition* by Plutarch, and the *Life of Aristippus* by Diogenes Laertius; the translation into Latin verse of the *Fables* of Lokman; *Diatribe Fl. Josephi de Jesu Christo testimonium suppositum esse*; *Epistolarum partes II.*, Saumur, 1659, 1665, in two vols. 4to; *Les Vies des Poëtes Grecs*, 1665, in 12mo, to which is subjoined *Le Mariage de Belfégor*, translated from the Italian of Machiavelli, and the Life of Theseus, translated from the Greek of Plutarch; *Méthode pour commencer les Humanités Grecques et Latines*, in the *Mémoires de Littérature* of Sallengre; *Notes* on the *Scaligeriana Prima*. (See *Mémoires pour servir à la Vie de Tannegui Lefevre*, by Fr. Graverol, 1686; and the *Mémoires de Nicéron*.)

FEZ, an extensive country of Africa, and at one time the most flourishing kingdom in the northern part of that continent. It now, however, forms a province of the empire of Marocco.

Fez, or Fas, the capital of the above kingdom, was built in 793 A.D., by a prince named Edris, and having soon risen to be a city of the first magnitude, became the capital of the western Mohammedan states. In the twelfth century it is said to have contained seven hundred temples and mosques, and other public edifices, a number of which were erected upon a magnificent scale, and adorned with a profusion of marble pillars. It was at one time held in the

when it is considered, that if we had the feudal law before it came into England, it must have been taken from some other people than the Normans, with whom we had no commerce." (*Essays upon several subjects concerning British Antiquities*, p. 4. Edinb., 1747, 8vo.) Of such random assertions as these, it would be superfluous to attempt a formal refutation.

highest veneration; and when the road to Mecca was shut up, in the tenth century, pilgrimages to Fez were performed by the western Moslems, who considered it as a place nearly equally sacred with that where the Prophet had been born. It was also distinguished for its learning, at a time when the Saracens may be said to have enjoyed a monopoly of all the knowledge which then existed. Its schools of philosophy, medicine, and astronomy, were famous throughout the Mohammedan kingdoms of Spain and Africa, and were not only resorted to by the youth of these countries, but likewise by Christians. When the Moors were driven out of Spain, Fez became the resort of numerous refugees, who, being superior in knowledge and civilization to their original countrymen, introduced several of the arts, the practice of which for a time retrieved the decaying fortunes of the city. But it gradually sunk with the declension of arts and wealth in Northern Africa; and when the kingdom of which it was the capital became incorporated with the empire of Marocco, it ceased to possess almost any political importance. Fez is situated in a funnel-shaped valley open only on the N. and N.E., and drained by one of the upper branches of the Seboo River, in N. Lat. 34. 6. 3., W. Long. 4. 58. 15. The vicinity is fertile and well cultivated, being covered with fields, gardens, and orange-groves. Fez consists properly of two parts, the old and the new town, the latter standing on a height and overlooking the former. In old Fez the streets are narrow, unpaved, and dirty, especially in rainy weather; and from the great height of the houses, are dark and gloomy. They are crossed at different intervals by high walls, which prop up the bulging and leaning walls of the buildings on each side. These cross-walls are perforated with arched passages, which being closed at night cut off all communication between one part of the city and another. The houses are built around court-yards, and have a mean and ruinous appearance. The windows are either very small or they are altogether wanting. The different stories are surrounded with galleries supported by colonnades, by means of which the adjoining rooms communicate. The new town is better laid out and built than the old one, and contains several palaces, numerous mosques, and other public buildings. The palace of the sultan is composed of a great number of court-yards which serve as entrances to the apartments. Fez at present contains about 100 mosques, which are all built on a uniform plan. They consist of a court-yard surrounded with arcades, and having on the S. side a covered square. The chief mosque, called *El Carubin*, was built during the flourishing period of the city, and is described by Leo Africanus as being a mile and a half in circumference. It possesses a great number of arches and gates, upwards of 300 pillars, and two handsome fountains in the court. The minaret contains globes and astronomical instruments brought from Europe, but they are now neglected, and most of them useless. The mosque dedicated to Edris, the founder of the city, is much frequented, and is a sanctuary for thieves and murderers. The public baths are numerous, and the city is abundantly supplied with water. The various trades and the different articles sold are divided into classes in separate streets, so that a whole street is occupied by those pursuing one traffic or art. Provision markets are numerous, and the inhabitants of the surrounding country daily resort in great numbers to the town as to a fair. Fez is still considered one of the principal seats of Mohammedan learning, and has schools attached to many of the mosques.

The manufactures of Fez consist of woollen *hhaïks*, sashes, and silk handkerchiefs, slippers of good leather, which they tan remarkably well, red felt caps, some coarse linen cloth, fine carpets, a curious kind of earthenware, weapons of several kinds, saddlers' ware, jewellery, and copper utensils. The arts here find little encouragement, and are indeed far inferior to those of Europe, except in the preparation of leather, and in the fabrication of carpets and of hhaiks, which the manufacturers know how to weave as fine and as transparent as gauze. They are also expert workers in wax, weapons, and harness. The heat during the summer is very great; but in other seasons of the year, particularly winter, the climate is agreeable. With regard to the number of inhabitants, much difference of opinion prevails among travellers.

FEZZAN, a country of considerable extent in Northern Africa. Its northern boundary is the village of Bonjem, which, according to Dr Vogel, is situated in Lat. 30. 34. 58. N. South of this point it extends six degrees and a half of latitude, or about 450 miles, and is bounded in that quarter by what are called the Wells of Meshroo. To the south and south-east is the country of the Tibboos, to the south-west that of the nomadic Tuaricks, and to the north-west the borderers are Arabs. Of this tract of country it is calculated that about 300 miles, stretching from north to south, are cultivated. The greatest breadth is estimated at 350 miles, the Black Haratch to the east and other deserts to the south and west being included in its territory. Fezzan may be said to consist of a chain of verdant islands embosomed in an ocean of sand. Fine yellow sand, and a species of gravel, cover the whole surface of the plains, except where the Soudah and Haratch extend. It is only in the immediate neighbourhood of towns that the palm is cultivated, and that corn and esculent plants, of which a little is raised with great difficulty and labour, are produced. The plains of the desert consist of red sand and sandstone, containing gypsum and rock-salt, associated with beds of dolomite and carbonate of lime. Soda, alum, saltpetre, and sulphur, are also found in this country.

In order to convey as clear and intelligible a view of Fezzan as possible, we shall follow the route generally pursued by travellers in proceeding from Tripoli to Mourzouk, the capital, and thence to the other parts of the country which have been described. Bonjem is a small place with 120 inhabitants, and a few small gardens, and is only 204 feet above the level of the sea. The water of the numerous wells is strongly purgative. About half a mile beyond the walls of Bonjem, which is the northern frontier, stands a Roman castle, situated among some high sand-hills. It is of an oblong form, having in the centre of each of the walls a large arched gateway, between two strong towers. After leaving this interesting ruin, the traveller proceeds over a barren desert called Klia, the soil of which, where clear of sand, consists of gypsum intermixed with numerous shells. Twelve miles south-south-east from Bonjem is that remarkable hill called the Bazeen, 70 feet high, and consisting of limestone. Further on is a similar hill called Khayrna, resembling a tent, and 120 feet high. Twenty-two miles from Bonjem the road leads through a defile called Hormut Emhalla, or the Pass of the Army. After crossing a range of table-mountains called Elood, running north-east and south-west, it passes through a stony and very uneven plain, encircled with mountains, to the pass of Hormut Tazzet, which appears to be situated about sixty miles from Bonjem. After clearing this pass, the road opens upon a plain called El Grarat Arab Hoon. The journey now becomes harassing, on account of the scarcity of vegetation and water, and the frequency of sand-winds. The first place of importance that is met with on this route is Sockna, near which are a plantation of palms and two wells of fresh water.

Sockna, which is about half way between Tripoli and Mourzouk, is situated on an immense plain of gravel 1036 feet above the level of the sea. It is bounded to the south by the Soudah Mountains, at the distance of about fifteen miles; to the eastward by the mountains of Wadan, at the distance of about thirty miles; to the westward by a distant range of hills; and to the northward by the country above

Fezzan.

described. The town, which is about a mile in circumference, is walled, and contains about 2500 persons. The streets are very narrow, and the houses are built of mud mixed with small stones. The water is almost all brackish or bitter. In the immediate neighbourhood there are several hundred thousand date trees, which pay duty to the government. Sockna pays of duty annually about 2000 dollars, exclusively of a tax of one dollar on every 200 date trees. The Tripoli money is the currency of Sockna; and this occasions a considerable loss to the traders who are obliged to pay their taxes in Spanish dollars, which they purchase at exorbitant prices. The dates grow in a belt of sand, at the distance of two or three miles from the towns; and their quality is far superior to any produced in the north of Africa, in consequence of which they bring a very high price in Tripoli. In the gardens situated about three miles from Sockna, barley, maize, a small quantity of onions, and a few other garden-stuffs, are cultivated. But there is little or no other kind of vegetation, so that all the animals are fed on dates. This place is infested with an immense quantity of flies, attracted probably by the dates, which are preserved in storehouses. The men have in general a clean and neat appearance, whilst the woman are pretty and handsome, but remarkable, it seems, for their love of intrigue. The latitude of Sockna is 29. 4. 4. N., the longitude 16. 18. 30. E.

East of Sockna stands the town of Hoon. It is smaller than the former, but is built and walled in the same manner. Palm groves and gardens approach close to the walls of the town, and completely conceal it. The soil is sand, but it is fertilized and refreshed by little streams from wells of brackish water. Twelve miles east by north of Hoon stands the town of Wadan. Its external aspect is pleasing, being built upon a conical hill, on the top of which are some enclosed houses called the castle; but internally it is inferior to the two other towns in point of neatness, comfort, and convenience. There is here a well of great depth, cut through the solid rock. The bulk of the inhabitants of Wadan are *schereefs*, that is, pretended descendants of the Prophet, and Arabs who act as shepherds. A few miles eastward of the town there is a chain of mountains, which, with the town itself, derives its name from a species of buffalo called *wadan*, which is found here in immense numbers. There is also a great abundance of ostriches amongst these mountains, by hunting which many of the natives obtain a subsistence. At all the three towns, Sockna, Hoon, and Wadan, it is the practice to keep tame ostriches in a stable, and in two years to take three cuttings of the feathers.

The whole way to Mourzouk is now an almost uninterrupted succession of stony plains and gloomy wadys, with no water but that of wells, generally muddy, brackish, or bitter, and placed at widely extended intervals. Sand winds also prevail, and their visitations are at all times harassing, and not unfrequently destructive. Several towns or villages are situated in this long and dreary waste, and they are usually encircled with groves of palm. Sebha, which stands in latitude 27. 2. 34. N., and 1380 feet above the level of the sea, is a mud-walled town picturesquely situated on a rising ground, and surrounded by a palm grove. Two marches farther on lies Ghroodwa, a small and miserable collection of mud huts. The palms here, which are the property of the sultan, extend from ten to fifteen miles east and west. The leading features of the above remarkable tract of country may be shortly described. The chain known by the name of the Soudah, or Jebel Assoud, that is, Black Mountains, commences near Sockna, and extends from north to south three days' journey, but in so tortuous a direction as not, according to Major Denham, to exceed thirty-five miles in a straight line, and only twenty-five according to Dr Vogel. To the westward they extend as far as the well of Assela, on the road to Shiati, a district to the westward of Sebha, where the red clay hills continue unbroken, and unite with those of Benioleed in Tripoli. To the east they extend three days to a wady called Temelleen, which lies on the way to Zella or Zula near Barca. They form, indeed, a branch or continuation of the mountainous desert called Haratch el Assouat, which was traversed by Horneman in his route from Cairo to Mourzouk. That traveller gives a fearful description of this wild region, so much dreaded by those who have had to traverse it. The mountain presents the appearance of an imperfect cone, and the rock, upon fracture, seemed to Horneman to consist of ferruginous basalt. Range upon range of black and dreary mountains, intersected by narrow and dismal ravines rather than valleys, rose before his view. Here and there, however, the eye was relieved by the sight of patches of vegetation, approaching even to luxuriance, from the rains which fall in this hilly region. Contiguous to the Black lies the White Haratch, a chain of mountains composed of friable limestone, and abounding in petrifactions. To the south of Sockna, the description of the Jebel Assoud, as given by Major Denham, exactly corresponds to that of the Black Haratch. Dr Oudney describes the hills as from 400 to 600 feet in height, the tops being in general tabular, but a few are irregular, and two or three terminate in conical peaks. The sides of all of them are covered with a considerable quantity of debris. The Black Mountains consist of yellow sandstone impregnated with iron, from which its crust receives a black colour, appearing in the sun's rays a deep blue. Large round patches of a yellow or brown colour are often seen on these black rocks, which give to the whole a most remarkable appearance. The summits are low and flat, and the valleys mostly circular or oval-shaped hollows, whilst the sides of the mountains are in many instances overhung by pillars, curved, inclined, and perpendicular. Animal and vegetable life is entirely absent in this region, which vividly recals to mind a landscape by moonlight. The whole exhibits a scene of barrenness which, according to Major Denham, cannot be perfectly described, either by poet or painter. After these dreary wastes have been passed, the hills of Zeghren commence. They run nearly east and west, are low, long, oval, and truncated at the top, and altogether different from any others which Denham and Oudney had seen. The town of Zeghren, according to the former traveller, is better built than any other in Fezzan.

Mourzouk, the capital of Fezzan, which, according to Dr Vogel, stands in latitude 25. 55. 16. N., and longitude 14. 10. 15. E., 1495 feet above the level of the sea, is a walled town, containing about 2000 inhabitants, very much mixed. The walls are built of mud, but sufficiently thick and high to guard the place from attack. As a substitute for stones, which are not to be found, the people use baked clay, a substance which is found sufficiently durable, as rain is here unknown. The houses are generally of one story; the doors are low and without hinges, but made to move upon a pivot. The streets are small and narrow, but there are numerous open spaces, destitute of buildings, and covered with sand, on which the camels of the traders remain. Many palms grow in the town, and a few red peppers and onions are cultivated. The street of entrance is a place about a hundred yards broad, leading to the walls which surround the castle, and is extremely elegant. The castle itself is an immense mud edifice, about ninety feet in height, and furnished with small battlements immensely broad at the base, but gradually tapering to about four feet in thickness at the top. Like all the rest of the buildings, the castle has no pretensions to regularity. It is the residence of the sultan, whose apartments are of the best quality, although, on account of the enormous mass of wall, all the rooms are of very small dimensions. The more spacious houses in Mourzouk are constructed in the manner which we shall

now endeavour to describe. A large door, sufficiently high to admit a camel, opens into a broad passage, in which there is a stable, and near it a room for slaves. Opposite the stable is a large square apartment, the roof of which is supported by palm trees. In the centre of the roof is an open space, through which the apartment is lighted, for all the houses are destitute of windows. There is generally a divan or seat of mud about eighteen inches high and twelve feet long. From the sides of the large room, doors open into the smaller ones, and a passage leads into a yard which has small houses attached to it, and a well. There are sixteen mosques in Mourzouk, which are covered in, but some of these are very small. The principal one is a low building, destitute of elegance. The burying places are outside the walls, and of considerable extent. Owing to the want of wood, no coffins are used; the bodies are merely wrapped in a mat or linen cloth, and covered with palm branches, over which the earth is thrown. The men of the lower orders of Mourzouk wear a large shirt of white or blue cotton, with long loose sleeves, trousers of the same, and sandals of camel's hide; but the shirt being in general long, many have no other covering. Those of the better sort, however, attire themselves more gaily; and their dress nearly resembles that of the people of Tripoli. The men have little beard, which they mostly keep closely clipped. The dress of the women here differs materially from that generally worn by Moorish females, and their appearance is by no means prepossessing. They plait their hair in thick bobbins, which hang over the forehead, and anoint it so profusely with oil that this liquid drips down over the face and clothes. From the back hair, however, ornaments of silver or coral are suspended. Other parts of the face and head, such as the ears, are profusely adorned. A woollen handkerchief is fastened to the back of the head, and falling over, is tied by a leather strap under the chin. A blue shirt is generally worn; and a jereed and red slippers complete their equipment. Some of the better class of women wear trousers, and all adorn their persons according to their rank and importance. Both men and women have a singular custom of stuffing their nostrils with a twisted leaf of onion or clover, which has a very disgusting appearance. The natives have a variety of dances, two or three of which are peculiar to the country. In Mourzouk the luxuries of life are very limited, the people subsisting principally on dates. Many of them do not taste corn for months together; but when obtained, it is made into cakes, which are baked in ovens formed of clay in holes in the earth, and heated by burning wood. Tobacco is very generally chewed by the women, as well as by the men; but smoking is the amusement of a great man only.

The revenues of the sultan of Fezzan arise from slaves, merchandise, and dates. For every slave that enters his dominions he receives two Spanish dollars (in some years the number of slaves amounts to 4000); for a camel's load of oil or butter, seven dollars; for a load of beads, copper, or hardware, four dollars; and for one of clothing, three dollars. All Arabs who buy dates pay a dollar of duty on each load before they are allowed to remove it; an impost which, at times, is equal to the market price of the article. Above 3000 loads are sold to them annually. Date trees, excepting those of the kadi and Mamelukes, are taxed at the rate of one dollar for every 200. By this duty, in the neighbourhood of Mourzouk, or, more properly, in the few neighbouring villages, the sultan receives yearly about 10,000 dollars. Of all sheep or goats he is entitled to a fifth. On the sale of every slave he has, in addition to the head money, a dollar and a half, which, at the rate of 4000 slaves annually, gives 6000 dollars. The captured slaves are sold by auction, at which the sultan's brokers attend, bidding high only for the finest. The trees which are his private property produce about 6000 camel-loads of dates, each of 400 lbs. weight, which may be estimated at about 18,000 dollars. Every garden pays a tenth part of the corn produced. The gardens are very small, and are watered with great labour from brackish wells, as rain is unknown, and dews never fall. Pomegranate trees and fig trees are sometimes planted in the water channels. Presents of slaves are frequently made and fines levied. Each town pays a certain sum, which is small; but as the towns are numerous, the average amount may be estimated at 4000 dollars. Add to this the annual excursions for slaves, sometimes bringing 1000 or 1500, of which one-fourth are the sultan's property, as well as the same proportion of camels. He alone can sell horses, which he buys for five or six dollars, when half starved, from the Arabs, who come to trade, and cannot maintain them, and makes a great profit by obtaining slaves in exchange for them. All his people are fed by the public, and he has no money to pay, excepting to the pasha, which was formerly 15,000 dollars per annum. There are various other modes by which he extorts money. If a man dies childless, the sultan inherits the greater part of his property; and if he thinks it necessary to kill a man, he becomes his sole heir.

In Mourzouk about a tenth part of the population are in a state of slavery. There are some white families, who are denominated Mamelukes, being descended from renegades whom the pasha had presented to the former sultan. These families and their descendants are considered as noble, and, however poor and humble their situation may be, they are not a little vain of their title.

The general appearance of the men of Fezzan is plain, and their complexion is black; the women are of the same colour, and ugly in the extreme. Neither sex is remarkable for figure, height, strength, vigour, or activity; and they have a very peculiar cast of countenance, which distinguishes them from other blacks. But they are a cheerful people, fond of dancing and music, and obliging to each other. The men almost all read and write a little; but in everything else they are very dull and heavy, their affections being cold and selfish, and a kind of general indifference to the common incidents of life marking all their actions. In Mourzouk the men drink a quantity of *lackbi*, as also a liquor called *busa*, which is prepared from dates. The Arabs generally practise hospitality; but amongst the Fezzanese that virtue does not exist. They are, however, very attentive and obsequious to those in whose power they are, or who can repay them tenfold for their pretended disinterestedness. Their religion enjoins that, should a stranger enter whilst they are at their meals, he must be invited to partake; but they generally contrive to evade this injunction by eating with closed doors. The lower classes are, from necessity, very industrious; but amongst people of rank industry is not a characteristic virtue. In regard to morals, they are much upon a level with the people of Tripoli, being both dishonest and insincere. Falsehood is not looked upon as odious unless it be detected.

The lower classes work neatly in leather. They weave a few coarse barracans, and work iron in a solid although clumsy manner. A few likewise work in gold and silver with tolerable skill; and every man is capable of acting as a carpenter or mason. The wood being that of the date tree, and the houses built of mud, very little elegance or skill is required in their construction.

From the constant communication with Bornou and with Soudan, the languages of both these countries are generally spoken, and many of their words are introduced into the Arabic; but the pronunciation is very different from that of the east. Their writing is in the Mogrebyn characters; but they have no idea of arithmetic, and reckon everything by dots on the sand, ten in a line. Though very fond of poetry, they are incapable of composing it. The Arabs, however, compose a few little songs, which the

natives have much pleasure in learning. The women are kept in a state of abject subordination, as is indeed common in all Mohammedan nations. The authority of parents over their children is very great, in fact unnecessarily despotic. There are no written records of events among the Fezzanese, and their traditions are so disfigured, and so strangely mingled with religious and superstitious falsehoods, that no confidence whatever can be placed in them. Several scripture passages are selected and believed. The Psalms of David, the Pentateuch, the books of Solomon, and many extracts from the inspired writers, are universally known, and most reverentially considered.

The only towns of any consideration in Fezzan, besides those already described, are Zuela, towards the eastern frontier, on the road to Egypt; Germa, to the west; and Gatrone, on the road to Bornou. In 1822, Dr Oudney and Captain Clapperton visited Germa. It is a walled town, and surrounded by a ditch. At a little distance from it stands the remains of ancient Germa, which appears to have occupied more space than the modern town. It was formerly the capital of Fezzan, and once gave its name to the nation of the Garamantes; at least, unless there are two places of the same name, this must be the ancient Garama, which is described by Pliny as a fine city, the capital of Fazania. The inhabitants of the modern town are very poor, and many of the houses are in ruins. The aspect of the country between this place and Mourzouk is similar to that of the other portions of Fezzan which we have already described. The hills, which stand about a hundred yards apart, are composed of sandstone, finely interstratified with beds of blue and white pipeclay and alum slate. There is a valley of considerable dimensions, and also several villages. The number of date trees in the eastern and western divisions of this valley is very great. There is here a town called Khraik, situated amidst some fine groves of palm trees, and possessing cultivated patches of ground and wells of good water.

The eastern and southern portions of Fezzan were visited by Captain Lyon. In latitude 25. 55. stands the town of Traghan, which was formerly a place as considerable as Mourzouk. It is situated in a flat desert plain, with its gardens and date groves at a short distance, and contains four mosques; but most of the houses, which are large, are in ruins, and the population is very trifling. Major Denham says that carpets are manufactured here equal to those of Constantinople. The route to Zuela lies entirely through salt plains and stony deserts, with here and there a small village. Zuela, or Zuila, is situated in latitude 26. 11. 48. It was formerly a considerable place, but is now only about a mile in circumference. It contains three mosques and three gates, but there are few good houses in it. The inhabitants are nearly all white; and Captain Lyon observes, that "they are certainly the most respectable, hospitable, and quiet people in Fezzan; and their whole appearance, for they are handsome, and very neatly dressed, bespeaks something superior to the other whites." At a short distance from Zuela are some very interesting ruins, one of them a castle, which must have been a place of great strength, on account of the immense thickness of the walls. These ruined fabrics have been much commented upon, but there is nothing to prove that they were of Roman origin. The next town of any importance is Gatrone, which stands in latitude 24. 47. 57. The country between Zuela and this place is a perfect desert, which in one place consists of a singular mixture of sand and salt. Gatrone is rather pleasantly situated. It is surrounded with sand hills and mounds of earth, covered with a small tree called *athali*. On leaving this place, Captain Lyon proceeded to Tegerhy, the southernmost town in Fezzan, and situated in Lat. 24. 4. N. Here the cultivation of the date and palm ceases, and the Arabic gives place to the Bornouese language. The desert comes close to the walls of the town, which is situated to the southward of its palms. The dates are here very fine and plentiful. Tegerhy is commanded by a fort, containing wells of water within the walls. A range of low hills extends to the eastward; and near the town are some salt pools, which are frequented by snipes, wild ducks, and geese. The natives are black, and little superior to savages.

Our information on Fezzan has recently been much enlarged by the expedition under Messrs Richardson, Barth, Overweg, and Vogel, particularly as regards the north-western and western portions of the country. Dr Vogel chose the usual road by Bonjem and Sockna, already described; but the former three travellers selected the western route, by Mizda, Ghareeah, and Hessi, which is very rarely followed, as being less practicable and agreeable to travel. There the Hamâda, a frightful desert of 1400 to 2000 feet mean elevation, and 110 geographical miles in width, has to be crossed. As far as the eye can reach, neither trees nor indications of wells are visible, and the scanty vegetation which occurs is only found here and there in the trifling irregularities of the surface. The ground is covered with small stones, pyramids of which, erected with great labour, serve as road-marks to the intrepid camel-drivers by day, while the Polar star and Antares are their guides by night. This desert plateau, which it took the expedition six long days' journey to cross, forms the boundary between Fezzan and Tripoli in that direction.

The southern edge of that tableland descends in perpendicular walks to the Wady el Hessi, where the black population and the dominions of Fezzan commence. Herbage and trees are here found, affording food to numerous gazelles, hares, and the wadan. South of Wady el Hessi, which is only 696 feet above the level of the sea, follows another barren region, ascending to 921 feet, and from 40 to 50 geographical miles in width, before Wady Shiati is reached, where some wells of good water are found, and palms, wheat, and barley, with a few figs and grapes, are cultivated. Between Wady Shiati and Wady Gharbi another sandy desert intervenes of nearly 60 geographical miles in width. It is composed of black sandstone, the disintegration of which forms a dark yellow sand, covering the inequalities of the stony surface, from which stands out prominently the black rock, in high cones of the most fantastic forms, strikingly representing basaltic rocks. The monotony of the dreary black rock is relieved by the yellow sand, without which the whole of Fezzan would be a lifeless wilderness, as it is in the sand that the palm trees grow, and in the wadys filled with it that the wells are found.

Wadi Gharbi, *i.e.* Western Wady, or Wady Lashal, or the Wady, comprises the most fertile region of Fezzan. It contains complete forests of palm-trees, through which peep a number of small villages, as well as cultivated fields of wheat and barley. It opens out on the east into the Wady Shergi, or Eastern Wady, and its elevation above the sea at the village of Ogrefah is 1192 feet.

In this journey from Mourzouk to Ghat, Messrs Richardson, Barth, and Overweg went almost due west, and kept nearly on the 26th parallel as far as the valley of Ghat. They discovered some extremely curious rock-sculptures in the Wady Tilissareh, which is situated in about 25. 58. N. Lat., and 12. 8. E. Long. One of these sculptures consists of two bird and bull-headed human figures, armed with spears, shields, and arrows, and combating for a child. The other represents a fine group of oxen going to a watering-place, most artistically grouped and skilfully executed. In the opinion of the travellers, the two works bear a striking and unmistakable resemblance to the sculptures of Egypt. They are evidently of a very high antiquity, and superior to numerous other sculptures of more recent date found at the same time, in which camels generally formed the principal object. They most probably relate to a period of an-

cient Libyan history, when camels were unknown in that part of Africa, and oxen were used instead.

As far as Tilissareh the road runs in a shallow wady called Barjouj, which is fringed on both sides with extensive plains, enlivened by numerous gazelles; only at some distance to the south, and nearly parallel with Wady Barjouj, rises a high range of sandstone hills. Wady Tilissareh is about 1800 feet high, and the ground keeps ascending other 30 miles further to the west, when the western edge of the tableland of Mourzouk is reached. The road there is cut through a narrow pass, consisting of blue marl, limestone, and sandstone. It seemed to the travellers to have been purposely cut out of the solid rock for the use of man, and reminded them of a railway excavation. As they advanced it assumed the form of a cave, slightly open at the top—narrow, winding, and furnished with seats on either hand. A dim light came from above. Now and then the pass became quite a tunnel, but the concave roof being high enough for any camel to pass. Little openings, containing groups of tholukh, now and then made a pleasant impression, but the general aspect of the pass was horrible and desolate. From the gorge the plain of Taceta opens out to the west, an arid region, covered with pebbles and blocks of sandstone and limestone, and at the western end of this plain, in the meridian of 11° Long. E., the western boundary of Fezzan is considered to be.

Dr Vogel has made very interesting observations on the botany of Fezzan, the principal results of which may here be alluded to. Unfortunately the vegetation between Tripoli and Mourzouk was mostly dried up when he traversed that region, the time being the height of summer. Within Fezzan every vestige of wild plants had disappeared, save a shrubby *Tamarix* and a spinous *Papilionacea*, called agûl by the Arabs, and used as fodder for the camels. For days in succession he perceived no other plants but date-palms, under which the drifting sand of the desert, the bane of vegetation, had accumulated to a considerable height, as if attempting to bury even these trees under its deadly mantle.

Respecting the cultivated plants of Fezzan, the inhabitants grow in the gardens of Mourzouk several kinds of grain and culinary vegetables with great labour. During the winter barley and wheat are cultivated, during the summer ghussub and ghafuly. The ghafuly mozri, so often mentioned by African travellers, is the Indian corn (*Zea mais*), the spikes of which are gathered before they are quite ripe, and in this state they are roasted and eaten. So small is the agricultural produce in this part of the world that the inhabitants cover each spike of the ghussub and ghafuly abiad with a neatly-made basket, in order to prevent the wild pigeons from picking the seeds. Amongst the few trees growing near Mourzouk the finest is a *Cornus*, called kurno by the Arabs; it attains a height of 80 feet, and a thickness of about 3 feet in diameter. Its chief native land is Soudan, and the latitude of 26° N. appears to be its northernmost limit. The gum acacia enlivens and adorns the most stony sides of the valleys of the Wady Shergi and Gharbi. The gum of the trees near the roads is collected by the caravans and used as food. This article is brought in considerable quantity by the Tuaricks from the regions between Wadys Gharbi and Ghat. The senna plant, the chief native country of which is Aïr, was found by Dr Vogel in a spot near Djerma in Wady Gharbi.

In the *materia medica* of the Arabs, *Peganum Harmala*, vernacularly termed harmel, occupies a prominent place. It is used as a preventative against ophthalmia. For that purpose a dozen of its seed-vessels are swallowed by the natives in the spring, fancying that in so doing they will be exempt from all diseases of the eyes. The plant ranges from the coasts of Tripoli to Fezzan, and is very common. Another common plant is a species of *Cucurbitacea*, known by the name of colocynth, the fruits of which are eaten by the ostriches. This *Cucurbitacea* occurs in great abundance in the valleys of the Black Mountains, and forms a troublesome weed in the more fertile wadys of Fezzan. The Tibboos are very fond of the seeds; they roast them in the manner those of the pumpkin are occasionally done on the continent, after they have been previously soaked for twelve hours in water to deprive them of their bitter taste. The fruit itself is used against urinary complaints, and diseases of the sexual organs. The only ornamental flower in the small gardens of Fezzan is the sun-flower (*Helianthus annuus*), which grows to the height of eight to nine feet. There is a useful plant met with by Dr Vogel, which resembles in foliage the thorn. The bark of its root is used by the natives for tanning leather and dyeing it red; the charcoal of this shrub is used in manufacturing gunpowder. At Beniolid, in particular, the Arabs possess a great many secret powder-mills, in which an inferior article of gunpowder, for about 2s. a pound, is manufactured.

The date-palm is the most important of the cultivated plants of Fezzan. Of this tree Dr Vogel has given a complete history, of which only the following notes are extracted. All that country and half of Tripolitania are fed on that product. The huts of the poorer classes are entirely made of date-palm leaves, and the more substantial habitations consist chiefly of the same material; every door, every post, is made of date-palm wood, and the ceilings of the rooms are formed by its stems. The branches of the tree furnish the most common fuel. It is often brought from a distance of six to eight miles, a man's load consisting of two bundles, fetching about twopence. The fruit of the tree forms the food of both man and beast; camels, horses, dogs, all eat dates. Even the stones of this fruit are softened in water, and given to the cattle; for in many districts the cattle have no grass or any other herbage, except a little safshah (*melilotus*), which in Mourzouk is cultivated with almost as much care as the corn, and fetches the high price of about fourpence a bundle, which is not more than a good handful. The camels of Mourzouk are therefore often sent about 100 miles to the north to have sufficient pasture. The number of the date-palms cultivated is enormous. When Abdel Gelil besieged Sockna in 1829, he cut down no less than 43,000 trees, in order to compel the town to surrender; nevertheless there are still 70,000 left. Their produce is comparatively small, 100 full-grown trees yielding about 40 hundredweight of dates, worth at Mourzouk about 30s., but at Tripoli about four times that sum. The dates, after having been gathered, are dried in the sun, and when quite hard, buried in the sand. They may thus be preserved about two years, but generally after the first 18 months they are attacked by the worms, and in the beginning of the third year nothing is left of them but the stones. As an everyday food dates are considered very heating; in consequence they are not much used on the journey, as causing great thirst. The most relishing and wholesome way to eat them is when made into a paste, mixed with barley. When the heart of the leaves has been cut out, a sweet thickish fluid collects at that cavity, called lagbi, which is very refreshing, and slightly purgative. A few hours afterwards this fluid begins to ferment, becomes acid, and very intoxicating. From the ripe fruit a kind of treacle is prepared, used especially for coating leather bags or pipes to render them tight.

Dr Vogel also explored the celebrated Trona Lakes of Fezzan, of which he gives the following description:—

The Trona Lakes are situated in a desert of the most dreary and impracticable description, presenting a labyrinth of hills, undulations, valleys, precipices, and literally not one square yard of level ground; formed entirely of drifting sand, in which the camels sink up to their bellies. For carrying a tent and cooking apparatus, together with two water-pipes—in all about 350 lb. weight, no less than five camels

Fezzan.

were required, and nevertheless only $9\frac{1}{2}$ miles could be accomplished in eighteen hours. One of these sandhills, measured trigonometrically,—for the transport of the barometer was found impossible—was ascertained to be 530 feet above the adjoining lake. The whole of these lakes are situated along the northern side of Wady Shergi and Wady Gharbi. In the eastern portion of the former Dr Vogel found the remains of ancient towers built by the original inhabitants of Fezzan; and in Wady Gharbi, near the village of Kharaig, some extremely interesting ancient tombs. These tombs consisted of about 50 pyramids, mostly between 6 and 8 feet high, and 6 to 8 feet square at the bases, the sides corresponding precisely with the four cardinal points. Only two of these pyramids were 16 feet high. One of them was opened, and in the interior a carefully constructed tomb was discovered, with the skeleton of a child and some pearls and corals.

The Trona Lakes, and especially Bahr-el-Dood, were said to be bottomless, but Dr Vogel found the depth of the latter 18 feet at an average, and 24 feet where it was deepest. This lake contains the celebrated Fezzan worm or Dood. From the drawings sent home by Dr Vogel, Dr W. Baird of the British Museum has found it to be a species of the *Artemia* or brine shrimp, and has called it *Artemia Oudneyi*, from having been first seen and described by Dr Oudney. A full-grown specimen was measured by Dr Vogel and found to be $3\frac{7}{12}$ Paris lines (about a quarter of an English inch) in length, and $1\frac{3}{12}$ Paris lines (or about $\frac{1}{10}$ of an English inch) in breadth under the head. They are of a very pretty colour, and in their bright hues resemble those of the gold-fish. They are caught with cotton nets, in which are hauled up innumerable other insects and flies, with which the lake is filled; the whole is mixed with a red kind of date and made into a paste, which has a smell and taste similar to salt herring, and is eaten by the inhabitants of Fezzan, in place of meat, along with bazeen.

The pashalic of Fezzan is computed to contain about a hundred towns and villages, but the population is thought not to exceed 26,000. It is governed by a sultan, who, although in fact only a viceroy dependent upon the pasha of Tripoli, possesses absolute sway. In regard to climate, Fezzan cannot be considered as fortunate. In summer the heat is intense, and the south wind, which is very dry, and impregnated with sandy particles, is scarcely supportable even by the natives. The winter, on the other hand, is accompanied with a bleak and penetrating wind blowing from the north, the cold of which is painfully felt even by the natives of a northern climate. Rain falls seldom, and in small quantities; thunder is also rare, but tempests of wind frequently occur. With regard to the soil, we have already spoken at sufficient length. The revenue, as derived from sources already mentioned, is devoted solely to the maintenance of the sultan, his army, and court. The cadi and other officers of justice, the ministers of religion, and even the great officers of state are maintained from grounds set apart for this purpose, and which are covered usually with gardens, or woods of date trees. The office of cadi or chief judge, to which is also attached that of first minister of religion, is hereditary in a certain family. The military force by which the Turks hold possession of this vast but thinly-peopled territory is the very inconsiderable number of 630 men.

This country was well known to the ancients under the title of the *Phazania Regio*, and the country of the Garamantes, whose ancient capital has been recognised by Major Rennell in the modern Germa, as already noticed. The name of Fasan or Fezzan seems to have been imposed by the Saracens, when they overran Northern Africa and established the Mohammedan faith; and ever since it has continued to prevail.

Fiars Prices.

FIARS PRICES were originally instituted in Scotland for the purpose of ascertaining the value of the victual or grain rents, and feu-duties payable to the crown.

They were first ascertained by the exchequer upon the prices of grain returned by the sheriffs of counties. Afterwards it was left to the sheriffs themselves, who proceeded through means of a jury.

Chalmers, in his *Caledonia*, vol. ii., p. 317, dates the commencement of fiars in counties some time after 1617 at the earliest, but the commissary fiars were much earlier. The Commissary Court records mention them as far back as 1564. The Act 1584, cap. 22, alludes to an exchequer fiar; and there are many instances during the latter half of the seventeenth century to be found in the records of the Teind or Tythe Court, when the judge ordained payments to be made according to the sheriffs' fiars.

It is remarkable, however, that there is no act of parliament enjoining the striking or using the fiars prices, or regulating the procedure in taking the averages. The sheriffs of the several counties seem to have assumed the right of dictating the mode of procedure; consequently the manner of conducting this process is various, sometimes contradictory, and generally loose. Of late great dissatisfaction has been expressed with the manner in which the average prices of grain are ascertained, and proposals have been made for applying to parliament for an act for better regulating the fiars.

The English averages are more accurately attained. By act of parliament, there are 290 towns the market clerks of which send weekly to the general registrar in London statements of the quantity and price of all grain sold in their markets, from which the registrar makes up the weekly returns as published in the *Gazette*.

The Earl of Lauderdale, when sheriff of Edinburgh, seems to have been the first who passed an act, Feb. 22, 1722, by which he ordained the summoning of a jury of fifteen for striking the fiars, and laid down rules of procedure. But the contrariety of decisions in litigations before the civil courts relative to the fiars prices attracted the attention of the Court of Session, which passed an act of sederunt, Dec. 21, 1723, regulating the procedure in the fiars courts. It is, however, doubtful if the Court of Session had power to make such regulations; and it was afterwards acknowledged that it had no jurisdiction with regard to the sheriffs in striking the fiars, consequently the matter is now left in a great measure under the direction of the sheriffs themselves.

The mode of striking the Haddington fiars is this—the jury summoned by the sheriff takes the average of all the prices as the middle fiars, the average of all the prices above that rate is taken as the highest fiars, and the average of all the prices below the same rate is taken as the lowest fiars, and then two and a half per cent. is added to each class.[1]

In Scotland it has been found to be a fair and safe principle in letting farms on lease, that the whole or a certain portion of the rent should be paid in grain or in the *value* of so many bolls of wheat or barley, so that in the event of a great fall of prices during the currency of the lease, the tenant should not suffer, and on the other hand, that the landlord should reap a fair share of the advantage in a rise of prices. It is obviously, therefore, the interest of those who have to pay that the fiars should be struck upon a low average, whereas it is the interest of those who have to receive that the rate should be high; and it is believed that the fiars are generally a little below the true market prices.

A great many contracts are regulated by fiars prices besides grain rents. There are feu-duties payable both to the

[1] This seems to have taken its origin from there being three qualities of each description of grain in the county. The averages, as taken in Haddington, are generally higher than in the other counties of Scotland.

crown and private parties, grain teinds or tithes payable to titulars, the stipends of the Established Church clergy, which are always, as a general rule, awarded in victual (oatmeal or barley), the salaries of the parochial schoolmasters, &c.

As far as the counties of Scotland are concerned, Edinburgh may be taken as a fair average of the whole, and we have given a list of the fiars prices as struck in that county between 1740 and 1854. These prices are higher than they are in some counties, and lower than in others. They are under those of Haddingtonshire by from 5 to 10 per cent., but they may be taken as a fair average of the fiars prices over all the counties of Scotland.

The measure which was used in striking the fiars from 1740 (the earliest year in which the prices are recorded) to 1824 was the boll. The Linlithgow boll, which was used in most of the counties, was equal to 8-11ths of the imperial quarter. The Mid-Lothian boll was within a small fraction of the same. From 1825, the year when the prices ceased to be reckoned for bolls, they are given as in the following table in imperial quarters.

Fiars Prices—Mid-Lothian.

1740 is the earliest year for which the fiars prices were recorded for this county.

Year.	Best Wheat.	Best Barley.	Best Oats.	Year.	Best Wheat.	Best Barley.	Best Oats.
	Per Boll.	Per Boll.	Per Boll.		Per Imp. Qr.	Per Imp. Qr.	Per Imp. Qr.
1740	£1 2 11	£0 17 8	£0 14 6	1825	£3 0 8	£1 19 0	£1 5 2
1750	0 13 6	0 10 7	0 9 4	1826	2 16 8	1 18 0	1 7 4
1760	0 13 6	0 10 3	0 8 4	1827	2 8 8	1 10 0	1 2 8
1770	0 18 6	0 13 9	0 12 0	1828	3 14 0	1 18 0	1 4 8
1780	1 0 0	0 14 0	0 11 0	1829	2 12 8	1 10 4	1 1 8
1790	1 3 0	0 17 4	0 14 10	1830	2 18 8	1 13 4	1 6 8
1800	2 18 9	2 0 7	1 13 2	1831	2 17 4	1 13 4	1 3 4
1801	1 15 0	1 5 6	0 16 6	1832	2 9 0	1 9 0	0 18 10
1802	1 6 6	0 17 6	0 15 6	1833	2 8 0	1 7 0	0 18 0
1803	1 6 3	0 18 6	0 17 6	1834	2 0 8	1 8 10	1 0 0
1804	2 2 0	1 10 0	0 18 6	1835	1 13 6	1 7 5	1 0 0
1805	1 10 0	1 3 9	0 18 9	1836	2 14 0	1 12 0	1 7 6
1806	1 18 0	1 6 0	1 0 0	1837	2 14 7	1 7 9	1 1 3
1807	1 12 6	1 10 0	1 7 0	1838	3 5 0	1 16 6	1 8 0
1808	2 7 6	1 10 0	1 4 0	1839	2 16 0	1 14 8	1 4 8
1809	2 2 0	1 10 6	1 0 9	1840	2 16 8	1 9 0	1 2 10
1810	1 19 0	1 7 6	0 18 0	1841	2 13 6	1 10 8	1 1 2
1811	2 7 6	1 16 0	1 3 0	1842	2 5 0	1 7 6	0 19 0
1812	3 0 0	1 19 6	1 11 6	1843	2 11 6	1 13 0	1 1 0½
1813	1 15 6	1 11 6	1 1 6	1844	2 3 4	1 10 0	1 1 8
1814	1 9 6	1 4 6	0 18 3	1845	2 4 10	1 10 6	1 6 8
1815	1 5 0	0 18 0	0 14 3	1846	3 4 0	2 1 4	1 15 0
1816	1 19 7	1 11 7	1 5 11	1847	2 11 6	1 11 6	1 4 6
1817	2 0 0	1 13 0	1 3 0	1848	2 4 7	1 7 9	0 19 1
1818	1 17 6	2 0 0	1 4 0	1849	1 13 6	1 0 9	0 16 5
1819	1 12 6	1 2 0	0 17 6	1850	1 16 4	1 4 8	0 18 0
1820	1 10 6	1 0 0	0 16 3	1851	1 17 6	1 4 7	0 19 6
1821	1 8 0	1 0 0	0 15 4	1852	2 6 0	1 9 5	1 0 10
1822	1 0 6	0 19 6	0 15 0	1853	3 2 4	1 16 4	1 9 4
1823	1 9 0	1 5 7	1 0 0	1854	3 8 1	1 15 1	1 9 6
1824	1 11 11	1 10 0	0 17 10				

The average for all Scotland in 1847 was—wheat, L.2, 12s. 5d.; barley, L.1, 9s. 7d.; oats, L.1, 2s. 7d.
The average for Mid-Lothian was—wheat, L.2, 11s. 6d.; barley, L.1, 11s. 6d.; oats, L.1, 4s. 6d.

FIBRE (Lat. *fibra*), a fine thread or filament; a fine slender body, such as those of which flesh, nerves, plants, roots, &c., are composed. In our manufactures vegetable filaments and fibres are among the most important of the whole series of raw produce; furnishing thread, cloth, cordage, and the like. For these purposes the filamentous parts of the *Gossypium*, *Cannabis*, and *Linum*, or cotton, hemp, and flax, are commonly used. The fibres of other plants have been employed in different countries for the same uses. Putrefaction destroys the pulpy matter, and leaves the tough filaments entire. Different kinds of cloth are prepared in the east from the fibres of the bark of certain trees boiled in a strong lye. Some of these cloths are very fine, and approach to the softness of silk, but in durability fall short of cotton; others again are coarser and stronger, and much exceed cotton in durability. See Botany, vol. v., p. 69, and Flax. For the chemical properties of vegetable fibre, see Chemistry, vol. vi., pp. 515, 516.

FIBRIN, a peculiar organic compound, found both in vegetable and animal substances. Fibrin is a soft solid, white, insipid, inodorous, and insoluble in water. It is procured in its most characteristic state from animal matter. It exists in the chyle and in the blood, and constitutes the chief part of animal muscle; hence it must be regarded as the most abundant constituent of animal bodies. Fibrin may be readily obtained by agitating new-drawn blood with a bundle of twigs, when it will adhere to them in long reddish filaments, which may be rendered colourless by washing in cold water. When dried, fibrin becomes semitransparent. yellowish, and brittle. It is composed of 53·36 carbon, 19·69 oxygen, 7·02 hydrogen, and 19·93 azote. Fibrin is a most important element of nutrition, and is essential to the sustenance of carnivorous animals.

FIBULA (Lat. a *clasp* or *buckle*), the outer and smaller bone of the leg; so called from its connecting and giving firmness to the other parts. See Anatomy, vol. iii., p. 37.

FICHTE, Johann Gottlieb, an eminent German metaphysician, was born at Rammenau, a village of Lusatia, on the 19th of May 1762. His father was a ribbon manufacturer, and carried on a small trade in haberdashery. A wealthy person in the neighbourhood having been struck with the extraordinary genius which young Fichte displayed, put him to school, in order to give him an opportunity of cultivating his talents; but the boy becoming impatient of restraint, ran off, and was found sitting on the banks of the Saale, with a map, on which he was endeavouring to trace the way to America. From this period he seems to have prosecuted his studies in an extremely desultory manner; occasionally attending the lectures of the professors of Wittemberg and Leipsic, without devoting his attention exclusively to any particular science. Theology, however, appears to have been his favourite study; and this predi-

lection is conspicuous in many of his subsequent writings, which are distinguished by a singular mixture of philosophical and religious mysticism. When he left the university, his situation was by no means enviable. He possessed no fortune to enable him to indulge in the luxury of philosophical speculation; and, in spite of his decided aversion to every kind of constraint, he was compelled, by the necessity of his circumstances, to accept the situation of tutor in the family of a Prussian gentleman. But his residence in Prussia enabled him to cultivate the acquaintance of the celebrated philosopher of Königsberg, to whose judgment he submitted his first work, the *Critical Review of all Revelations*, which was published anonymously in 1792. In the literary journals, this production, which had attracted considerable attention, was ascribed to the pen of Kant, until the real author made himself known.

Having received fifty ducats from a Polish nobleman, in whose family he had been tutor, Fichte set out on a course of travels through Germany and Switzerland, and afterwards married a niece of Klopstock's at Zurich. In 1793, he published the first part of his *Contributions towards rectifying the Opinions of the Public respecting the French Revolution.* This book, which is written with considerable force and originality, created a great sensation in Germany, and was violently attacked, in consequence of a new and apparently dangerous theory which the author advanced relative to the social contract. The book,however, was perused with great avidity; but the attacks to which we have alluded probably prevented him from publishing the continuation.

The reputation of Fichte was now so well established, that he soon afterwards obtained an appointment to the philosophical chair at Jena, as successor to Reinhold, who had been called to the university of Kiel. Here he commenced his lectures by a programme, in which he endeavoured to give an idea of the *Doctrine of Science* (*Wissenschaftslehre*), the name by which he distinguished the principles of that system of transcendental idealism which he afterwards more fully developed. In 1794, besides the ordinary duties of his professorship, he every Sunday gave a regular couse of lectures, in the form of sermons, *On the Literary Calling*, which was numerously attended. Having established the principles of his doctrine of science, he endeavoured to extend their application to the several departments of philosophy; and with this view he published in 1796 his *Fundamental Principles of the Law of Nature*, and two years afterwards his *System of Morals.* In conjunction with Niethammer, he also published a philosophical journal, in which some articles were inserted, containing certain philosophical views of religion, which were considered by many as tending directly to atheism. Amongst a number of objectionable propositions, it was maintained that God was nothing else than the moral order of the universe; and that to worship God as a being who could only be represented as existing in time and space was a species of idolatry. One of Fichte's colleagues called the attention of the Saxon minister Burgsdorf to these heretical propositions; and the consequence was the rigorous confiscation of the work throughout the whole of Saxony. Fichte and his friend Forberg wrote an *Appeal to the Public*, and several *Apologies*, in order to exculpate themselves from the imputation of atheism. The government of Weimar behaved on this occasion with prudence and moderation; but the celebrated Herder, vice-president of the consistory, took part against Fichte. Eberhard, on the other hand, although hostile to the metaphysical system of Fichte, undertook his defence. The controversy was carried on with great violence, and excited considerable ferment throughout the whole of Germany.

In the meantime Fichte resigned his professorship at Jena, and repaired to Berlin, where he met with a very flattering reception. Here his time was occupied in giving private lectures, and in composing his various writings. In 1800 he published a short treatise, entitled *The Exclusive Commercial State*, containing one of those philosophical systems of political economy from which the praise of ingenuity cannot be withheld; whilst, at the same time, the most cursory view of the general principles on which it is founded must be sufficient to convince us that it could never be advantageously reduced to practice.

About this period Fichte met with a formidable rival in Schelling, who had formerly been a warm partisan of the *Doctrine of Science*, but who now separated from his master, and propounded a new metaphysical theory of his own, which soon acquired a large share of popularity at the German universities, especially at Jena. Fichte indeed endeavoured to modify his theory of the *Doctrine of Science*, and to present it to the world in a new and more attractive form; but he never again recovered the sway which he had formerly exercised over the public mind. Meanwhile, his ardent wish to be again placed in an academical chair was at length gratified by M. de Hardenberg, who in 1805 procured for him the appointment of ordinary professor of philosophy in the university of Erlangen. This appointment was accompanied with the especial favour of being permitted to pass the winter at Berlin, in order to continue his lectures there. But this state of amphibious professorship, as his friends used to call it in jest, did not last long. During the summer of 1805 he delivered at Erlangen his celebrated lectures *On the Essence of the Literary Character* (*über das Wesen des Gelehrten*). The following winter he delivered to a numerous audience the course which he afterwards published under the title of *Guide to a Happy Life.* This was one of those publications in which he attempted to present his metaphysical doctrines to the public in all their sublimity, and, at the same time, with such clearness, as should render them intelligible to common readers.

The disasters which assailed the Prussian monarchy in 1806 were attended with serious consequences to Fichte. Erlangen having ceased to be a Prussian university, he did not await the entry of the French into Berlin, but fled to Königsberg, and thence proceeded to Riga. In the summer of 1807 he delivered a course of philosophical lectures at Königsberg. The peace which ensued enabled him to return to Berlin, where he pronounced his famous *Orations to the German Nation*, which were enthusiastically read and applauded throughout all Germany. When the university of Berlin was founded, he obtained, through the interest of M. de Humboldt, the situation of rector, which secured to him an honourable revenue, whilst his rank as first professor of philosophy gave him great academical influence. His health, however, had suffered considerably from the shocks he had for some time experienced, and he found it necessary to have recourse to the waters of Bohemia, from which he derived great benefit. But his wife was attacked with a nervous fever, in consequence of her attendance on the deserted sick; and although she recovered, Fichte, whose affection would not allow him to leave her for a moment, caught the infection, and died on the 29th of January 1814.

Fichte was small in stature, but stout and well formed; his countenance was expressive of thoughtfulness and determination. In his intellectual character, genius was combined with inflexible firmness; and these qualities enabled him to surmount difficulties which would have overwhelmed a man of less vigorous temperament. In other respects his dispositions were amiable and his morals correct. It was in the academical chair that the genius of Fichte was manifested in its greatest splendour. It was said of him that he was born a professor; and there was indeed a charm in his manner of lecturing which had a powerful influence on the minds of his pupils, many of whom were in the habit of talking of him with enthusiasm. His fervid and brilliant eloquence, the clearness of his reasoning, and the simplicity and correct-

ness of his language, seemed to diffuse a magic light and colouring over the darkest and most abstruse metaphysical problems. Those who were charmed with his eloquence were easily convinced by his reasoning, and became willing converts to his doctrines. His writings, especially those works in which his peculiar doctrines are propounded in a systematic form, are by no means so attractive as his lectures appear to have been. On the contrary, notwithstanding a constant affectation of strict and simple reasoning, his propositions are enveloped in such a degree of transcendental obscurity, as renders it extremely difficult to comprehend either the basis or the scope of that system of doctrines which he laboured to establish.

Hence it is far from being an easy matter to give an intelligible abstract of the principles of the *Doctrine of Science*, especially as we must necessarily presuppose some acquaintance, on the part of our readers, with the previous metaphysical labours of Kant. Fichte commenced his philosophical career precisely at that period when the writings of Kant had nearly obtained a paramount influence on the German schools, and when men even of superior talents thought it no mean glory to be able to comprehend and illustrate his doctrines. The Kantian theory was confessedly idealistic. Its celebrated author set out with an analysis of the cognitive faculty, and endeavoured to describe its various functions, as well as to ascertain the scope and limits of its legitimate exercise. All our knowledge, according to the critical philosophy, must have a reference to possible experience. Of external objects, or things in themselves (*noumena*), we can have no absolute knowledge; for we can know nothing but what is perceived by the senses, and cognized (if we may be allowed the expression) by our intellectual faculties, according to the laws peculiar to our constitution. These intellectual laws, or subjective forms, tend to combine our knowledge, and to render the field of experience a comprehensible whole. As we can have no knowledge of objects in themselves, but only of their *phænomena*, neither can we have any knowledge of things beyond the sphere of our experience, because these can neither be perceived by our senses nor subjected to the laws of the understanding. All reasoning, therefore, from mere ideas must necessarily be futile, because it has no reference to any corresponding object within the limits of experience. And although we can have no absolute knowledge of objects as they really exist, yet our knowledge of them possesses a subjective reality (that is, a reality with reference to the thinking subject), and may be said to correspond with the objects, because, from the nature of our intellectual constitution, we are incapable of receiving any other impression from them.

Reinhold was one of the earliest partisans of Kant, and one of the most ingenious and most popular commentators on the critical philosophy. But his talents were better adapted for explaining and illustrating the doctrines of others, than for discovering new truths, or inventing any original system of his own; and although an indefatigable student of philosophy, he seems to have never arrived at any settled conviction in metaphysical matters, but to have alternately adopted and abandoned every new theory which was successively presented to his view. After having been for some time enthusiastically devoted to the doctrines promulgated in the *Critical Review of Pure Reason*, which he esteemed the greatest masterpiece of philosophical genius, he at length discovered that Kant had neglected to secure the foundations of the edifice he had raised, and this defect he attempted to supply by his own *Theory of the Faculty of Perception* (*Theorie des Vorstellungsvermögens*). The main proposition laid down and illustrated in this work is nothing more or less than this: We are compelled by consciousness to admit that every perception presupposes a percipient subject and an object perceived, both of which must be distinguished from the perception to which they relate; thus referring all our knowledge to consciousness as its ultimate principle. In the enunciation of this proposition there is nothing very new or original; but the illustration of this elementary doctrine, which, as a late reviewer of the German metaphysical theories observes, might have formed an excellent subject for a short philosophical dissertation of two or three sheets, is dilated into a work nearly as large as that to which it was intended to serve as a mere introduction; nor is the unnecessary length of the treatise in any measure compensated by the importance of the truths developed, or the ingenuity displayed in the research.

With greater talents and consistency, Fichte, who announced himself as a strict Kantian, attempted to resolve the same problem, and to develop a system which, by deducing all our knowledge from one simple principle, should give unity and stability to the critical theory. In his *Doctrine of Science* (*Wissenschaftslehre*), accordingly, he derives all our knowledge from the original act of the thinking subject in reflecting upon itself. *I am I* (which he expresses by the formula $A = A$), or the absolute position of the I by the I, is in itself the certain principle of all philosophy and of all our knowledge. But the creative energy of the I, in the course of this reflective process, goes still further. By its own act, also, the I places the *not-I* (objects) as opposed to itself. In reflecting upon itself, as the absolutely active principle, it finds itself either determined by or determining the *not-I*. In the former case, it appears as the *intelligent I;* in the latter, as the *absolutely free, practical I.* Hence the distinction between theoretical and practical philosophy. The idea, then, which pervades the whole theory of Fichte is this: The I, or the thinking subject, is the absolutely active principle, which *constructs* the consciousness, and produces all that exists, by position, contraposition, and juxtaposition. The whole universe, in short, is the product of the I, or thinking subject.

We have thus endeavoured to give a very concise sketch of a theory which we shall not think of pursuing through its various ramifications, as we should despair of making it intelligible to our readers by any length of exposition. Fichte has been praised by his countrymen for his logical and consistent reasoning; but to us it appears that his theory proceeds entirely upon arbitrary assumptions, resting upon no solid foundation. That he displays considerable ingenuity in the development of his ideas we are willing to admit; but we are quite at a loss to perceive the merit of the theory he has advanced, when considered as a system of philosophical truths. The parade of scientific deduction which his reasoning exhibits may impose upon the incautious student; but a careful examination will undoubtedly convince him that the whole is a mere tissue of empty notions, derived from arbitrary and assumed principles.

In attempting to apply the principles of his doctrine of science to the theory of morals and the law of nature, Fichte exhibited many original and paradoxical opinions, along with some very just and ingenious philosophical observations. In his later writings he considerably modified his original theory of the doctrine of science, and produced a system of philosophical and religious mysticism, which appears to have given birth to the transcendental idealism of Schelling, an author who seems to have carried the extravagance of speculative reasoning to its utmost limits.

The following is a list of the works of Fichte:—*Versuch einer Kritik aller Offenbarung* (Critical Review of all Revelation), Königsberg, 1792, 1793, 8vo; *Ueber den Begriff der Wissenschaftslehre* (On the notion of a Doctrine of Science), Jena, 1794, 8vo; *Grundlage der gesammten Wissenschaftslehre* (Foundation of the whole Doctrine of Science), Ibid. 1794, 8vo; *Grundriss des eigenthümlichen der Wissenshaftslehre* (Sketch of the peculiarity of the Doctrine of Science), Weimar, 1794; *Vorlesungen ueber die Bestimmung des Gelehrten* (Lectures on the Literary Calling), Jena, 1794; *System der Sittenlehre* (System of the Doctrine of Morals), Jena and

Leipsic, 1795; *Beyträge zur Berichtigung der Urtheile des Publicums ueber die Französische Revolution* (Materials for Rectifying the Opinions of the Public respecting the French Revolution); *Grundlage des Naturrechts* (Foundation of the Law of Nature), Jena, 1796, 1797, 2 vols. 8vo; *Appellation an das Publicum ueber die ihm beygemessenen atheistischen Aeusserungen* (Appeal to the Public respecting the atheistical expressions imputed to him), Jena and Leipsic, 1799; *Ueber die Bestimmung des Menschen* (On the Destiny of Man); *Der geschlossene Handlesstaat* (The exclusive Commercial State); *Sonnenklarer Bericht an das grössere Publicum ueber das eigentliche Wesen der neuesten Philosophie* (Luminous Report to the greater public on the peculiar Character of the modern Philosophy), Berlin, 1801; *Wissenschaftslehre* (Doctrine of Science), Tübingen, 1802, 8vo; *Vorlesungen ueber das Wesen der Gelehrten* (Lectures on the Literary Character), Berlin, 1806; *Die Grundzuge des gegenwärtigen Zeitalters* (The Characteristics of the Present Age), Ibid. 1806; *Anweisung zum seligen Leben* (Guide to a Happy Life), Ibid. 1806; *Reden an die Deutsche Nation* (Discourses to the German nation) Ibid. 1806; *Die Wissenschaftslehre in ihrem allgemeinsten Umrisse dargestellt* (The Doctrine of Science exhibited in its most general outline), Ibid. 1810; *Freidrich Nicolai's Leben und Sonderbare Meinungen, herausgegeben von Schlegel* (Life and singular opinions of Frederick Nicolai, edited by Schlegel), Tübingen, 1801; *Antwortschrieben an K. L. Reinhold, auf dessen Beyträge zur leichtern Uebersicht des Zastandes der Philosophie*, &c. (Answer to K. L. Reinhold, on his Materials for acquiring a more easy View of the State of Philosophy, &c.), Tübingen, 1801; *Ueber die einzig mögliche Störung der academischen Freyheit* (On the only possible disturbance of Academical Freedom), Berlin, 1812; *Ueber den Begriff des wahrhaften Kriegs, in Bezug auf den Krieg in jahre*, 1813 (On the notion of real war, with reference to the war in 1813), Tübingen, 1815.

Fichte is also the author of several essays in periodical publications, and particularly in a philosophical journal edited by himself, with the assistance of Niethammer.

Those who are desirous of obtaining more minute information respecting Fichte's philosophical theory, may consult the following works: Tennemann's *Grundriss der Geschichte der Philosophie*; Degerando, *Histoire Comparée*, &c. W. T. Krug, *Briefe ueber die Wissenschaftslehre*. F. W. J. Schelling, *Darlegung des wahren Verhältnisses der Naturphilosophie zu der verbesserten Fichtischen Lehre*. J. Fries, *Reinhold, Fichte und Schelling*. C. F. Bachmann, *Ueber die Philosophie meiner Zeit*. Ancillon, *Essai sur le premier problème de la philosophie*; and *Essai sur l'existence et sur les derniers systèmes de métaphysique qui ont paru en Allemagne*. (J. C.)

FICHTELGEBIRGE, a mountain group of Germany, in Bavaria, forming the centre from which three extensive mountain ranges proceed,—the Erzgebirge in a N.E., the Frankenwald in a N.W., and the Böhmerwald in a S.E. direction. The streams to which it gives rise flow towards the four cardinal points,—*e.g.* the Eger flowing eastward and the Saale northward, both to the Elbe; the Main westward to the Rhine, and the Naab southward to the Danube. The chief points of the mass are the Schneeberg and the Ochsenkopf, the former having a height of 3433 and the latter of 3340 feet.

FICINO, Marsilio, a distinguished Italian scholar, was born at Florence in 1453. Instead of devoting himself, as the fashion of that age was, to the study of Aristotle, he selected Plato as his favourite author; and may be considered as the restorer of that philosopher's doctrines in the west. He translated the whole of his works into Latin, besides portions of those of his most celebrated followers, such as Plotinus, Proclus, Porphyrius, and Jamblicus. He died at Correggio in 1499; and we are informed by Baronius that after his death he appeared to his friend Michaele Mercato, to whom he had promised to manifest himself as a confirmation of his doctrines regarding the immortality of the soul. His collected works appeared first at Venice in 1516, and were afterwards reprinted at Basil and at Paris.

FICUS, a large genus of urticaceous plants, in which the male and female flowers are mixed indiscriminately on the inside of a hollow, turbinate, fleshy receptacle. The genus comprehends the various species of fig-trees, which are all either tropical or inhabitants of warm countries. Some of these are shrubs or small creeping plants; while others are among the largest trees of the forest. The species of *ficus* have alternate leaves and branches, and secrete a milky juice more or less acrid, and which exists even in the common eatable fig in its unripe state. Upwards of 100 species are known, of which the following are among the most interesting.

1. *Ficus Carica*, a small tree which produces the common eatable fig, is a native of Asia, Africa, and the south of Europe, and has been cultivated from remote antiquity on the shores of the Mediterranean. This tree grows from 15 to 25 feet high, and the trunk sometimes attains a diameter of two feet. It has rough, lobed, deciduous leaves; the flowers are minute, unisexual, and contained in great numbers in a common receptacle, which is fleshy, turbinate, and almost closed at its apex. The male flowers (which are comparatively very few in number) occupy the superior part of this receptacle, while the lower and all the remaining part is filled with the female flowers. It is this receptacle, with its multitude of minute flowers imbedded in the pulp, which when ripe constitutes the well-known fruit. In its fresh state the fig is generally of a purplish hue, and has a soft, sweet, fragrant pulp. At least fourteen varieties are cultivated in this country, generally under glass, or in warm sheltered situations. As the cultivated fig-tree bears, for the most part, female flowers only, an artificial method of fertilizing them is resorted to in the Levant. This is the interesting process called *caprification*. The fact of this artificial impregnation is mentioned by Aristotle, who observed that a certain insect was generated on the flowers of the caprifig (wild fig), which, having become a fly, entered the unripe fruit of the domestic fig and caused it to set. Tournefort and other travellers describe the process of caprification as practised in the Levant as follows:—At a particular season branches of the wild fig are placed among the cultivated trees, and the fertilizing pollen of the wild plant is conveyed by the legs and wings of these insects (a species of *Cynips*) into the interior of the receptacle. To insure success, it is requisite to observe the proper period for this operation, which should be performed just before the insects will be ready to take wing, otherwise they might be lost. The same artificial method of fecundation with regard to the date-palm was practised in early times, according to Herodotus, by the Babylonians, who used to suspend male clusters from wild dates over the females, though they appear to have regarded the small flies found among the wild flowers as the direct cause of the fertility of the females. This process, which was called *palmification*, was also known to the Egyptians, the Phœnicians, and other nations of Asia and Africa.

Dried figs constitute a principal article of sustenance among the lower classes in Greece and the islands of the Archipelago. The quantity imported into Britain in 1853 amounted to 50,428 cwts. The best come from Turkey, Italy, Spain, and Provençe; but the Turkish figs are most esteemed.

2. *Ficus sycamorus*, or Egyptian Sycamore, is a large tree with widely-spreading branches, and produces a delicate eatable fruit, which does not grow upon the tender branches, but in clustered racemes on the trunk and old limbs. It is planted extensively in Egypt on the highways for the sake of the grateful shade it affords. A specimen of this tree, much gnarled and broken, is figured in Salt's *Abyssinia* under the name of *Daroo* tree. Some have supposed that the Egyptian mummy-cases were made of the wood of this tree, which would imply a wonderful degree of durability; but Professor Don is rather of opinion that the timber of *Cordia Myxa* was the material employed for that purpose.

3. *Ficus indica*, the Banyan tree, has been celebrated from antiquity for the peculiar mode of its growth. It has a woody stem, branching to a great height and vast extent, with heart-shaped entire leaves terminating in acute points. Some of these trees are of amazing size and extent, as they

are continually increasing. Every branch from the main body throws out its own roots, at first in small tender fibres, several yards from the ground; but these continually grow thicker until they reach the surface, and then striking in, increase to large trunks, and become parent trees, shooting out new branches from the top, which again in time suspend their roots, and these, swelling into trunks, produce other branches, till at length a single tree forms a little forest. From its long duration, its outstretching arms, and overshadowing beneficence, the Hindus regard the banyan tree as an emblem of the Deity. Near these trees the most esteemed pagodas are generally erected; under their shade the Brahmins spend their lives; and the natives of all castes and tribes are fond of recreating in the cool recesses, beautiful walks, and lovely vistas of this umbrageous canopy, impervious even to the direct rays of a tropical sun. The most celebrated tree of this kind is one on the banks of the Nerbudda, which has been known, in the march of an army, to afford shelter to 7000 men. Much of this remarkable tree has been swept away by high floods, but the remaining portion is said to be near 2000 feet as measured round the principal stems. The name *banyan* is derived from *baniyâ*, *i.e.* a banker—the class among the Hindus with which Europeans formerly had most frequent intercourse. A representation of a banyan tree is given under BOTANY, vol. v., p. 77, fig. 65.

4. *Ficus religiosa*, the pippul tree, is a large tree common to many parts of India, and is regarded with great veneration by the Hindus as having given shelter to Vishnu at his birth. It is often planted near houses for the sake of its umbrageous canopy; and its leaves, which are heart-shaped, long, and pointed, tremble like those of the aspen. They are employed by the Arabs in tanning leather.

5. *Ficus elastica*, which affords a large supply of the caoutchouc of commerce, abounds in Assam, and is plentifully distributed over some other parts of India. The method of obtaining the juice has been described under the head CAOUTCHOUC. It is a fast-growing tree, with large, shining, pointed, thick leaves, and produces a fruit about the size of an olive, but which is not eatable.

FICTION. In a *general sense* a fiction is something feigned or imagined, and in the most extensive acceptation of the word anything which is unreal may be characterized as a fiction. In a *moral sense* a fiction is a culpable falsehood, or rather an imposture, as it always supposes the intention of deceiving. In a *literary sense* fiction assumes a different character. It is employed to produce an illusion, and it is indispensable to its success that it should appear in the guise of truth; nevertheless there is no intention here to make that which is false pass for being true. Works of fiction include novels, tales, romances, and even epic poems. In a *legal sense*, a fiction is something assumed for the purposes of justice though not literally true; thus an heir is held to be the same person as his ancestor in order to make him liable for the debts of him whose estates he has inherited. In a *political sense*, a fiction is that which, though literally untrue, is sanctioned by considerations of expediency for the preservation of order and security. Such is the received axiom in constitutional monarchies, "that the king can do no wrong," the intention of which is to establish the principle that the ministers are responsible for all the acts of the crown. A similar axiom is, that "the king never dies;" that is, it can never be said of the sovereign that he is dead, because on the moment of his decease there lives a sovereign in the person of his successor.

FID, a square bar of wood or iron passed through the hole in the heel or lower part of a topmast, and resting by its ends on the trestle-trees of the mast below; thus serving to support the topmast. Fid also denotes a pin of wood or iron tapered to a point, for opening the strands of a rope in splicing, &c.

FIDDES, RICHARD, a laborious English writer, born at Hunmanby near Scarborough, in 1671. Having received his grammatical education at a private school in the neighbourhood, he was admitted first of Corpus Christi, and then of University College, Oxford; but, after taking the degree of bachelor of arts, in 1693, he returned to his relations, and married the same year a lady of good family and fortune. In 1694 he was ordained priest, and not long afterwards presented to the rectory of Halsham; but was compelled by bad health to remove to Wickham, where he continued for some time. Being thus unable to display his talents as a preacher, he resolved to devote himself to literature, and with this view proceeded to London in 1712, where, by the favour of Swift, he was introduced to the Earl of Oxford, who made him one of his chaplains, and procured for him a similar appointment from the queen. But the change of ministry in 1714 overturned all Fiddes' hopes of preferment, and forced him to apply to writing with greater assiduity than ever. In 1718 he was honoured with the degree of doctor by the university of Oxford. He died in 1725. Dr Fiddes was an ingenious but not very learned man; he possessed a retentive memory, and was capable of the most intense application; his publications were more numerous than interesting; his style as a writer is tedious and prolix, and, though commonly judicious, he almost never rises above mediocrity. His misfortunes, towards the close of his life, were chiefly owing to his connection with that party in the state to which, through Swift, he had been led to attach himself upon his arrival in London. (J. B—E.)

FIDDLE. See MUSIC, and VIOLIN.

FIDE-JUSSOR, in the *Civil Law*, is a surety, or one who obliges himself in the same contract with a principal, for the greater security of the creditor or stipulator.

FIDEI-COMMISSUM, in the *Civil Law*, an estate left in trust with any person, for the use of another.

FIDENÆ (now CASTEL GIUBILEO), in *Ancient Geography*, an old and important Latin city, on the left bank of the Tiber, about five miles from Rome. It is said by Livy to have owed its origin to the Etruscans; but his testimony is not supported by that of any other historian. The idea of its Latin origin is that now generally received. The proximity of Fidenæ to Rome, and its jealousy of the rising power of that state, soon brought the two cities into collision; indeed there is no Latin city which plays so important a part in the annals of regal Rome as Fidenæ, which was not only powerful in its own resources, but by its connection and alliances with other Latin states. Hostilities first broke out between the two cities in the time of Romulus, and continued with little intermission and various success till 496 B.C., when, being abandoned by its allies, it was forced to yield to the Roman arms. In 438 B.C. the Fidenates revolted, slew the Roman ambassadors, and for twelve years maintained an unequal contest with their powerful neighbours. At the end of that time, however, their city was taken and plundered, and the inhabitants sold into slavery. From this time Fidenæ appears no more in history as an independent city. In the later times of the republic and under the empire, Fidenæ continued a small country village, and is mentioned by Horace as almost proverbially lonely and desolate. In the reign of Tiberius it acquired a dismal notoriety from a fearful accident which happened in its neighbourhood. An extraordinary gladiatorial show had attracted vast multitudes of spectators from Rome and the surrounding country, and the temporary wooden amphitheatre in which they were accommodated fell during the exhibition, and destroyed nearly 50,000 persons. No ruins of Fidenæ now exist; but the site of the city has been ascertained beyond a doubt at the modern Castel Giubileo.

FIDES, among the Romans, the personification of faithfulness or fidelity, in whose honour Numa is said to have

erected a temple on the Capitol. No animals were immolated, nor was any blood spilt, in the sacrifices to this deity. Fides was represented as a matron crowned with olive or with laurel, and bearing ears of corn or a basket of fruit in her hand. The ancients also worshipped a god called Fidius, who was supposed to preside over promises and alliances. Fidius was properly a surname of Jupiter, and identical with the Sabine *Sancus* or *Semo*.

FIEF, a term borrowed from the French, and applied to an estate in lands held of a feudal superior. See Fee.

FIELD, John, one of the most celebrated pianoforte-players of his age. He was born in the year 1782, in Dublin, where his father held an appointment as violinist at the Theatre Royal. He learned the principles of pianoforte-playing from his grandfather, who was an organist, but displayed little industry or zeal in the cultivation of his art till the removal of the family to London in 1798, when he was placed under the tuition of Clementi. He became the favourite pupil of this great master, and accompanied him to the Continent in 1802. He made a brillant debut in Paris, enjoyed similar success at Vienna, and thence proceeded with Clementi to Russia, where he spent the greater part of his life. He died at Moscow in 1837. The peculiar characteristic of Field's playing was its extreme delicacy, precision, and gracefulness. The musical compositions of Field, consisting of seven concertos, a quintetto, sonatas, variations, fantasias, &c., display those excellences for which his own performance was distinguished.

FIELD, in *Heraldry*. See Heraldry.

FIELD-MARSHAL, the highest military title in England and some other countries. The term is derived, through the German *feld-marschall*, from the *maréchal de camp* in the old French service. In England the number of field-marshals rarely exceeds five or six; they have no pay and no especial authority as such; but they retain their full pay as generals.

FIELD-OFFICERS, in the army, officers above the rank of captain; as majors and colonels.

FIELDING, Henry, one of the greatest of English novelists, was born at Sharpham-Park, Somersetshire, on the 22d of April 1707. His father, General Edmund Fielding, who had served under John Duke of Marlborough, was the third son of Dr John Fielding, canon of Salisbury, who was the fifth son of George Earl of Desmond, and brother of William the third Earl of Denbigh; and his mother, the general's first wife, was a daughter of Judge Gould. He was also connected with the noble family of Kingston, which, in the celebrated Lady Mary Wortley Montague, boasted a brighter ornament than rank or title could bestow. Henry Fielding was the only son of the first marriage; but he had four sisters of the full blood, one of whom, Sarah, was distinguished as an authoress by the history of *David Simple*, and other literary attempts. General Fielding, after the death of his first wife, married a second time, and had a numerous family of sons, one of whom is still remembered as a judge of police by the title of Sir John Fielding. The expense attending so large a family, together with a natural thoughtlessness of disposition on the part of his father, of whose habits economy formed no part, were probably the occasion of Henry being early involved in those embarrassments with which, excepting at brief intervals, he continued to struggle through life.

After acquiring the rudiments of education under the Rev. Mr Oliver, who is supposed to have furnished him with the outline of Parson Trulliber's character, young Fielding was removed to Eton, where he made great progress in the study of the Greek and Roman authors, and imbibed that deep love of classical literature which may be traced throughout all his works. As his father destined him for the bar, he was, at the age of eighteen, sent from Eton to Leyden, where he remained about two years, and is said to have given the most earnest attention to the study of the civil law. Had he been permitted to continue the pursuit in which he had thus engaged, the courts would probably have gained an accomplished lawyer, and the world would have lost a man of genius; but the circumstances of the father determined the chance in favour of posterity, though against the interests and perhaps the welfare of the son. Remittances, in short, failed, and the young civilian was compelled to return, at the age of twenty, to plunge into the dissipation of London, without a monitor to warn or a friend to support him. His father had indeed promised him an allowance of two hundred pounds a year; but this, as Fielding himself used to observe, any one might pay who would. Possessed of a strong constitution, a lively imagination, and a keen relish of pleasure, with the capacity of enjoying the present and trusting to chance for the future, Fielding thus found himself his own master in a place where the temptations to every expensive indulgence are numerous, and the means of gratification easily attainable; and, with reckless improvidence, he squandered in pursuit of pleasure the scanty means which, with strict economy, might have enabled him to begin the world, at the same time entailing upon himself those distresses and misfortunes in which he was ever afterwards involved.

But as disagreeable impressions never remained long upon his mind, and as it was his disposition to look at the brighter side of things, or rather to enliven the gloomiest prospect with the colours which his own fancy cast upon it, he flattered himself that he would find resources in his own wit and genius, and that the difficulties in which he was involved would be overcome by the exertions which he conceived himself capable of making to surmount them. To a man of pleasure, in fact, some resources were indispensably necessary, and Fielding found them in his pen, having no alternative, as he himself used to say, but to become a hackney writer or a hackney coachman. He at first employed himself in writing for the stage, then in high reputation, from having recently engaged the talents of Wycherley, Congreve, Vanburgh, and Farquhar; his comedies and farces were brought out in hasty succession; between the years 1727 and 1736, play succeeded play, to the number of eighteen, which were struck off as his necessities impelled, and sank oftener than swam in the theatrical sea upon which he cast them. Of these, the only pieces now known or read are the mock-tragedy of *Tom Thumb*, the translated play of *The Miser*, and the farces of *The Mock-Doctor* and *Intriguing Chambermaid;* and yet, as Sir Walter Scott justly observes, they are all the production of an author unrivalled for his conception and illustration of character in the kindred department of imaginary narrative. Whilst Fielding was thus living as a man of wit and pleasure about town, seeking and finding amusement in scenes of gaiety and dissipation, and endeavouring to discharge the expense incidental to such a life by the precarious resources afforded by the stage, which, as may easily be supposed, were inadequate for the purpose, he attempted to improve his circumstances by becoming himself the manager of a company; and having, in 1735, assembled a number of discarded comedians, he proposed that they should perform his own plays, at the little theatre of the Haymarket, under the whimsical title of the Great Mogul's company of comedians. But the project, as might have been expected, did not succeed; and the company, which seemed to have dropped from the clouds, were under the necessity of disbanding. The whole scheme, in fact, has more the air of a mad frolic than of a serious undertaking. During his theatrical career, which, we have just seen, was by no means brilliant, Fielding, like most authors of the time, found it impossible to interest the public sufficiently

Fielding. in the various attempts which he made to gain their favour, without condescending to flatter their political animosities. In two of his dramatic pieces, *Pasquin* and the *Historical Register*, he displays great acrimony against Sir Robert Walpole, whom, in the year 1730, he had in vain attempted to propitiate by some courtly verses. The keenness of the satire made it felt, and its freedom is supposed to have operated considerably in producing a measure which was then thought necessary to restrain the licentiousness of the stage, and to check that proneness to personal and political satire which had been fostered by the success of the *Beggars' Opera*. But this measure, which consisted in vesting a discretionary power in the Lord Chamberlain to refuse a license to any piece which he should disapprove, was very unpopular at the time, and, like all petty legislation, has done mischief which was not intended by it, and failed to accomplish the object for which it was designed.[1]

About the year 1736, Fielding having, it seems, formed the resolution of settling in life, espoused a young lady of Salisbury, named Craddock, possessed of considerable beauty, and of a fortune of L.1500; and, about the same time, he succeeded, in right of his mother, to a small estate of L.200 per annum, situated at Stower in Derbyshire. With this fortune, which, managed with prudence and economy, might have afforded a decent competence, he retired from London to his seat in the country, resolved to bid adieu to the follies and irregularities of a town life, and to cultivate habits of domestic enjoyment. But having unfortunately carried with him the same improvident disposition to enjoy the present at the expense of the future, which marked his whole life, he soon forgot all his resolutions of amendment; established an equipage with showy liveries; threw open his gates to unbounded hospitality; and suffered his whole substance to be devoured by horses, hounds, retinue, and entertainments. Thus, in less than three years, Fielding found himself landless, homeless, penniless, without any other resource than his abilities, and having brought nothing from the country except that experience of rural life and its pleasures which afterwards enabled him to delineate with such inimitable truth and force the character of Squire Western. Not discouraged, however, he entered himself as a student of law at the Temple, and, after the customary term of manducation, was called to the bar. Fielding had now a profession, and, as he had vigorously applied his powerful mind to the study of the law, it might have been expected that his success would have been in proportion to his assiduity. But various causes conspired to obstruct his rise in the legal profession. In the first place, those persons who have it in their power to advance or retard the practice of a young lawyer, seem to have mistrusted the capacity of a man of wit and pleasure for steady application to business; and Fielding's own conduct was in all probability such as to justify this want of confidence in his regularity. In the next place, disease, the consequence of a free life, came to the aid of dissipation of mind, and interrupted the course of his practice by severe attacks of the gout, which gradually undermined his naturally robust constitution. But amidst all this difficulty and suffering, he pursued his researches with great though irregular vigour; and, as a proof of the eminence to which, in happier circumstances, he might have risen at the bar, he left two manuscript volumes in folio on the Crown Law; a branch to which he had most assiduously applied himself. The exigencies of a family, to which he was tenderly attached, forced him however to have recourse again to the stage, where he attempted to produce a continuation of his own piece, *The Virgin Unmasked;* but as one of the characters was supposed to have been written in ridicule of a man of quality, the Lord Chamberlain refused his license. Political pamphlets, fugitive tracts, newspaper essays, and sometimes farces, were the next means he had recourse to for subsistence; and as his ready pen supplied such productions upon every emergency, he contrived out of the scanty profits to support himself and family. But amidst the anxiety and labour of this precarious mode of life, he had the misfortune to lose his wife; a domestic calamity which so deeply affected him that his reason was for a time endangered by the excess of his grief. All violent emotions, however, are happily transient; Fielding recovered from the blow which had stunned him, though his regret was lasting; and the necessity of procuring subsistence compelled him to resume his literary labours. At length, in the year 1741 or 1742, circumstances led him to engage in a species of composition which he rescued from the degraded state in which he found it, and rendered a classical department in English literature.

The novel of *Pamela*, published in 1740, having raised the fame of Richardson to the highest pitch, Fielding, whether tired of hearing it overpraised,[2] or whether, as a writer for subsistence, disposed to catch at whatever interested the public for the time, or whether, finally, seduced by that malicious spirit of wit which delights to turn into ridicule the idol of the day, resolved to caricature the style, the principles, and the personages of this favourite performance. As Gay's desire to satirize Philips produced *The Shepherd's Week*, so Fielding's purpose to ridicule *Pamela* suggested *The History of Joseph Andrews;* but, in both cases, more especially the latter, a work was executed of infinitely greater merit than could have been expected to arise out of such a design; and the reader received a higher gratification than the author himself appears to have proposed or contemplated. In Fielding's novel there is indeed a fine vein of irony, as will appear from comparing it with the pages of *Pamela;* but the production against which the ridicule was directed is now almost forgotten; whilst *Joseph Andrews* continues to be read for its admirable pictures of manners, and, above all, for the inimitable character of Parson Adams, which alone is sufficient to decide the superiority of Fielding over all novel writers. "His learning, his simplicity, his evangelical purity of mind," says Sir Walter Scott, "are so admirably mingled with pedantry, absence of mind, and the habit of athletic and gymnastic exercises, then acquired at the universities by students of all descriptions, that he may be safely termed one of the richest productions of the muse of fiction. Like Don Quixote, Parson Adams is beaten a little too much and too often; but the cudgel lights upon his shoulders, as on those of the honoured knight of La Mancha, without

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[1] "The regulation," says Sir Walter Scott, "was the cause of much clamour at the time; but licentious satire has since found so many convenient modes of access to the public, that its exclusion from the stage is no longer a matter of interest or regret; nor is it now deemed a violent aggression on liberty that contending political parties cannot be brought into collision within the walls of the theatres, intended, as they are, for places of amusement, not for scenes of party struggle." (*Memoir of Fielding.*) This is no doubt true; but has not the theatre suffered in consequence of the regulation by which all political allusions are excluded from the stage, whilst neither the amount of licentious satire, nor its facilities of gaining access to the public, have been, in the slightest degree, diminished?

[2] This production, many passages of which would now be thought highly indelicate, and condemned as suggestive of licentious ideas, was in those days recommended even from the pulpit. Modern refinement, though it may not have succeeded in banishing immodesty from the heart, has at least had the effect of purifying literary compositions of that grossness which, more or less, deforms almost all those of the last age.

Fielding. the slightest stain to his reputation; and he is bastinadoed without being degraded."[1] *Joseph Andrews* was eminently successful; and poor Richardson, whose greediness of praise was only equalled by his extreme sensitiveness to ridicule, felt proportionally offended; whilst his admirers, male and female, took care to echo back his resentment, and to heap Fielding with reproach. The animosity of the idol and his worshippers, in fact, survived the gifted man who had rendered them all ridiculous; and in Richardson's correspondence we find the most ungenerous, not to say malignant, reproaches cast on his memory.[2] But Fielding does not appear to have retorted any of the ill-will in which Richardson and his coterie indulged. If he gave the first offence without provocation, he was also the first to retreat from the contest, and to leave his exasperated antagonists in undisputed possession of the field. Nor was Fielding slow in conceding to Richardson that praise to which his genius entitled him from the liberality of his contemporaries. In the fifth number of the *Jacobite Journal*, he warmly commends *Clarissa Harlowe*, by far the best and most powerful of Richardson's novels, and which, with those scenes in *Sir Charles Grandison* relating to the history of Clementina, contains the passages of deep pathos on which his fame as a writer must finally rest. "Perhaps this is one of the cases," says Sir Walter Scott, "in which one would rather have sympathized with the thoughtless offender, than with the illiberal and ungenerous mind which so long retained its resentment."

After the publication of *Joseph Andrews*, Fielding had again recourse to the stage, and brought out *The Wedding-Day*, which, though upon the whole unsuccessful, produced him some little profit. This was the last of his theatrical efforts which appeared during his life-time. The comedy of *The Fathers*, in manuscript, was lost by Sir Charles Hanbury Williams, and, when recovered, was performed after the author's death, for the benefit of his family.[3] Besides a variety of fugitive pieces, Fielding published, in 1743, a volume of miscellanies, containing, amongst other things, *The Journey from this World to the next;* a tract of which it is difficult to perceive the scope or aim, although it displays a good deal of Fielding's characteristic humour. His next production was *The History of Jonathan Wild the Great;* a picture of desperate vice, unrelieved by a single indication of human feeling, or even by an accidental deviation into virtue. What object Fielding could have proposed to himself by so revolting a delineation, it is not easy to conjecture. For, besides the disgust produced by the contemplation of wickedness naked and unredeemed, every one must feel, that ascribing a train of fictitious adventures to a real character, has in it something clumsy and inartificial; whilst, on the other hand, it subjects the author to a suspicion of having used as the title of his book the name of an infamous depredator, in the hope of connecting the one with the popular renown of the other. At the same time, there are not many passages in Fielding's works more strongly marked with his peculiar genius, than the scene between Jonathan Wild and the Ordinary, in Newgate. Besides these more permanent proofs of his application to literature, Fielding employed his ready pen in most of the political and literary controversies of the times. He conducted one paper, called *The Jacobite Journal*, the object of which was to eradicate those feelings and sentiments which had already been so effectually crushed on the field of Culloden; and he either entirely composed or had a principal share in *The True Patriot* and *The Champion*, periodicals of the same class. Being attached to the principles of the Revolution, and to the settlement of the succession in the family of Brunswick, he steadily advocated what was then called the Whig cause; but whilst far inferior writers were enriched out of the secret-service money with unexampled prodigality, his zeal and ability remained long unnoticed, and never met with any suitable recompense.

As it was impossible, however, that such a man could be altogether overlooked, Fielding, in 1749, received a small pension, together with an appointment as a justice of peace for Westminster; an office then considered as disreputable, and of which he was at liberty to make the most he could by the worst means he chose. At this period the magistrates of Westminster, being paid by fees for their services to the public, were thence termed trading justices; and in general they appear to have deserved this opprobrious appellation; for the mean and wretched system on which they were remunerated making it their interest to inflame petty disputes, to wring out of thieves and pickpockets a portion of their unhallowed gains, and thus to traffic, as it were, in guilt and misery, seemed equally well calculated to encourage crime, and to degrade those whose ostensible duty it was to repress it. The habits of Fielding, who was never very select in his society, cannot be supposed to have

[1] The style of this piece is said in the preface to be an imitation of Cervantes; but it bears more resemblance to that of the *Roman Comique* of Scarron, from whom Fielding appears to have copied the mock-heroic style, which narrates ludicrous events in the language of the classical epic; a vein of pleasantry, however, which is soon wrought out, and which, if frequently employed, is apt to degenerate into pedantry.

[2] Richardson, being well acquainted with Fielding's sisters, took occasion to complain to them, not of their brother's usage of himself (this would have been natural and honest), but of his unfortunate predilection for what was mean and low in character and description. The following passage is remarkable, first for the unexampled presumption of the writer, who thus constitutes himself the judge paramount of Fielding's qualities; and, secondly, for the malignant indelicacy which could obtrude such observations on the sister of a rival: "Poor Fielding! I could not help telling his sister that I was equally surprised at and concerned for his continued lowness. Had your brother, said I, been born in a stable, or been a runner at a spunging-house, one should have thought him a genius, and wished he had had the advantage of a liberal education, and of being admitted into good company!" The man who could be guilty of such deliberate brutality as is here complacently chronicled, would not have scrupled to employ more criminal means to gratify his animosity, if he had not been restrained either by innate cowardice or a salutary fear of the laws. After this, however, we cannot be surprised to find Richardson alleging that Fielding was destitute of invention and talents; that the run of his best works was nearly over; and that, as an author, he would soon be forgotten!

[3] The following anecdote, which is given by former biographers, shows the carelessness of Fielding respecting his reputation as a dramatist: "On one of the days of its rehearsal (that is, the rehearsal of *The Wedding-Day*), Garrick, who performed a principal part, and who was then a favourite with the public, told Fielding he was apprehensive that the audience would make free with him in a particular passage, and remarked that, as a repulse might disconcert him during the remainder of the night, the passage should be omitted; "No, d—n 'em," replied he; "if the scene is not a good one, let them find *that* out." Accordingly the play was brought out without alteration, and, as had been foreseen, marks of disapprobation appeared. Garrick, alarmed at the hisses he met with, retired into the green-room, where the author was solacing himself with a bottle of champagne. He had by this time drank pretty freely; and, glancing his eye at the actor, while clouds of tobacco issued from his mouth, cried out, "What's the matter, Garrick? what are they hissing now?" "Why, the scene that I begged you to retrench," replied the actor; "I knew it would not do; and they have so frightened me that I shall not be able to collect myself again the whole night." "Oh, d—n 'em," rejoined he, with great coolness, "they *have* found it out, have they?"

been improved by the position into which he was now thrown; and from a humiliating anecdote told by Horace Walpole,[1] in his usual lively but unfeeling manner, it would appear, even after allowance is made for the aristocratical exaggeration of the narrator, that his mind had sunk to the level of his situation. Yet, though the circumstances attending his official situation tended to foster the careless and disreputable habits which he was unfortunately but too prone to indulge, it is consoling to observe that Fielding's principles remained unshaken, and that there is no foundation whatever for the imputation of venality which, from the popular discredit attaching to his office, and his own thoughtless extravagance, the ill-natured world were at one time but too ready to cast upon him. His own account of his conduct respecting the dues of the office on which he depended for subsistence has been confirmed by Mr Murphy, and never doubted or denied. "I will confess," says he, "that my private affairs at the beginning of winter had but a gloomy aspect; for I had not plundered the public, or the poor, of those sums which men, who are always ready to plunder both as much as they can, have been pleased to suspect me of taking; on the contrary, by composing instead of inflaming the quarrels of porters and beggars (which, I blush when I say, hath not been universally practised), and by refusing to take a shilling from a man who most undoubtedly would not have had another left, I had reduced an income of L.500 a year, of the dirtiest money upon earth, to little more than L.300, a considerable portion of which remained with my clerk." Nor was this all. Whilst Fielding thus evinced his disinterestedness as a magistrate, he endeavoured, by various suggestions, to check the growth of crime and depravity. His *Inquiry into the Increase of Thieves and Robbers* contains several valuable hints which succeeding statesmen have adopted, and some which have not yet received the attention they deserve. He was the first to expose the injurious effects of the frequency of pardons, rendered necessary by the reckless multiplication of capital punishments; and he had the merit of directing public attention to that swelling imposthume of the state, pauperism, with the consequences to be apprehended from the state of the poor laws and the mode in which they were administered. He afterwards published a scheme for the provision of the poor, which showed that he was fully sensible of the evil, without being able to suggest an effectual or practical remedy; but although his project for restricting them to their parishes, and providing for them in workhouses, was not approved of, it has never been disputed that his treatise exhibits both the knowledge of the magistrate and the picturesque expression of the novel writer. He also published a *Charge to the Grand Jury of Middlesex*, and some *Tracts concerning Law Trials*, which are considered as valuable.

Before publishing his scheme for the provision of the poor, however, Fielding made himself immortal by the production of *Tom Jones, or the History of a Foundling*; a work composed under all the disadvantages incident to an author alternately harassed by his disagreeable magisterial duties, and pressed by the necessity of hurrying out some ephemeral essay or pamphlet to meet the demands of the passing day.[2] In these painful and precarious circumstances was the first of English novels given to the public, who had not hitherto seen any works founded upon the plan of painting from nature, and who, consequently, were quite unprepared for a work constructed on such a principle. Even Richardson's novels are but a step removed from the domain of the old romance; and, though approaching more nearly to the ordinary course of events, still resemble it by dealing in improbable incidents, exaggerated delineations, and characters swelled out beyond the ordinary proportions of humanity. *Tom Jones*, on the other hand, is truth and human nature itself, and therein consists the incalculable advantage which it possesses over all previous fictions of this particular kind. Fielding is the Hogarth of novelists; and he painted manners with the hand of a master. *The History of a Foundling* was received with unanimous acclamation by the public, and proved so productive to Millar, the publisher, that he handsomely added L.100 to the L.600 for which he had purchased the work from the author.

"The general merits of this popular and delightful work," says Sir Walter Scott, "have been so often dwelt upon, and its imperfections so frequently censured, that we can do little more than hastily run over ground which has been so repeatedly occupied. The felicitous contrivance and happy extrication of the story, where every incident tells upon and advances the catastrophe, while at the same time it illustrates the characters of those interested in its approach, cannot too often be mentioned with the highest approbation. The attention of the reader is never diverted or puzzled by unnecessary digressions, or recalled to the main story by abrupt and startling recurrences; he glides down the narrative like a boat on the surface of some broad navigable stream, which only winds enough to gratify the voyager with the varied beauty of its banks. One exception to this praise, otherwise so well merited, occurs in the story of the Old Man of the Hill; an episode which, in compliance with a custom introduced by Cervantes, and followed by Le Sage, Fielding has thrust

[1] "Rigby gave me a strong picture of nature. He and Peter Bathurst, t'other night, carried a servant of the latter's, who had attempted to shoot him, before Fielding, who, to all his other vocations, has, by the grace of Mr Lyttleton, added that of Middlesex justice. He sent them word he was at supper; they must come next morning. They did not understand that freedom, and ran up, where they found him banquetting with a blind man, a wh—, and three Irishmen, on some cold mutton, and a bone of ham, both in one dish, and the dirtiest cloth. He never stirred or asked them to sit. Rigby, who had seen him come so often to beg a guinea of Sir C. Williams, and Bathurst, at whose father's he had lived for victuals, understood that dignity as little, and pulled themselves chairs, on which he civilized." (*Letters from the Hon. Horace Walpole to George Montague, Esq.* p. 58, London, 1818.) It ought to be added, however, that Walpole, though he has here stigmatized the lowness of Fielding's society and habits, has elsewhere done justice to his talents. In *The Parish Register of Twickenham*, or poetical account of that place, Fielding's residence in the neighbourhood is not forgotten; that residence,

Where Fielding met his bunter muse,
And as they quaff'd the fiery juice,
Droll nature stamp'd each lucky hit
With unimaginable wit.

[2] *Tom Jones* is inscribed to the Hon. Mr, afterwards Lord Lyttleton, in a dedication where he intimates that, without his assistance, and that of the Duke of Bedford, the work would never have been composed, inasmuch as the author had been indebted to them for the means of subsistence whilst engaged in composing it. Ralph Allen, the friend of Pope, is also alluded to as one of his benefactors, but, by his own desire, not named. This modest and munificent patron of merit is said to have made Fielding a present of L.200 at one time, and that before he was personally acquainted with the object of his bounty; an act of rare generosity, and, from the manner in which it was performed, fully confirming the truth of Pope's beautiful couplet:—

Let modest Allen, with ingenuous shame,
Do good by stealth, and blush to find it fame.

into the midst of his narrative, as he had formerly introduced the History of Leonora, equally unnecessarily and inartificially, into that of *Joseph Andrews*. It has also been wondered why Fielding should have chosen to leave the stain of illegitimacy on the birth of his hero; and it has been surmised that he did so in allusion to his own first wife, who was also a natural child. A better reason may be discovered in the story itself; for had Miss Bridget been privately married to the father of Tom Jones, there could have been no adequate motive assigned for keeping his birth secret from a man so reasonable and compassionate as Allworthy.

"But even the high praise due to the construction and arrangement of the story is inferior to that claimed by the truth, force, and spirit of the characters, from Tom Jones himself down to Black George the game-keeper and his family. Amongst these, Squire Western stands alone; imitated from no prototype, and in himself an inimitable picture of ignorance, prejudice, irascibility, and rusticity, united with natural shrewdness, constitutional good humour, and an instinctive affection for his daughter,—all which qualities, good and bad, are grounded upon that basis of thorough selfishness, natural to one bred up from infancy where no one dared to contradict his arguments or to control his conduct. In one incident alone we think Fielding has departed from this admirable sketch. As an English squire, Western ought not to have taken a beating so unresistingly from the friend of Lord Fellamar. We half suspect that the passage is an interpolation. It is inconsistent with the squire's readiness to engage in rustic affrays. We grant a pistol or sword might have appalled him; but Squire Western should have yielded to no one in the use of the English horsewhip; and as, with all his brutalities, we have a sneaking interest in the honest jolly country gentleman, we would willingly hope there is some mistake in this matter.

"The character of Jones, otherwise a model of generosity, openness, manly spirit, mingled with thoughtless dissipation, is, in like manner, unnecessarily degraded by the nature of his intercourse with Lady Bellaston; and this is one of the circumstances which incline us to believe that Fielding's ideas of what was gentleman-like and honourable had sustained some depreciation, in consequence of the unhappy circumstances of his life, and of the society to which they condemned him.

"A more sweeping and general objection was made against the *History of a Foundling* by the admirers of Richardson, and has been often repeated since. It is alleged, that the ultimate moral of *Tom Jones*, which conducts to happiness, and holds up to our sympathy and esteem a youth who gives way to licentious habits, is detrimental to society, and tends to encourage the youthful reader in the practice of those follies to which his natural passions and the usual course of the world but too much direct him. French delicacy, which on so many occasions has strained at a gnat and swallowed a camel, saw this fatal tendency in the work, and by an *arrêt* discharged the circulation of a bungled abridgment by De la Place, entitled a translation. To this charge Fielding himself might probably have replied, that the vices into which Jones suffers himself to fall are made the direct cause of placing him in the distressful situation which he occupies during the greater part of the narrative; whilst his generosity, his charity, and his amiable qualities, become the means of saving him from the consequences of his folly. But we suspect with Dr Johnson, that there is something of cant both in the objection and in the answer to it. 'Men,' says that moralist, 'will not become highwaymen because Macheath is acquitted on the stage;' and we add, they will not become swindlers and thieves because they sympathize with the fortunes of the witty picaroon Gil Blas, or licentious debauchees because they read *Tom Jones*. The professed moral of a piece is usually what the reader is least interested in; it is like the mendicant, who cripples after some splendid and gay procession, and in vain solicits the attention of those who have been gazing upon it. Excluding from consideration those infamous works, which address themselves directly to awakening the grosser passions of our nature, we are inclined to think, the worst evil to be apprehended from the perusal of novels is, that the habit is apt to generate an indisposition to real history and useful literature; and that the best which can be hoped is, that they may sometimes instruct the youthful mind by real pictures of life, and sometimes awaken their better feelings and sympathies by strains of generous sentiment and tales of fictitious wo. Beyond this point they are a mere elegance, a luxury contrived for the amusement of polished life, and the gratification of that half love of literature, which pervades all ranks in an advanced stage of society, and are read much more for amusement than with the least hope of deriving instruction from them. The vices and follies of Tom Jones are those which the world soon teaches to all who enter on the career of life, and to which society is unhappily but too indulgent; nor do we believe, that in any one instance the perusal of Fielding's novel has added one libertine to the large list, who would not have been such had it never crossed the press. And it is with concern we add our sincere belief, that the fine picture of frankness and generosity exhibited in that fictitious character has had as few imitators as the career of his follies. Let it not be supposed that we are indifferent to morality, because we treat with scorn that affectation which, while in common life it connives at the open practice of libertinism, pretends to detest the memory of an author who painted life as it was, with all its shades, and more than all the lights which it occasionally exhibits, to relieve them. For particular passages of the work, the author can only be defended under the custom of his age, which permitted, in certain cases, much stronger language than ours. He has himself said, that there is nothing which can offend the chastest eye in the perusal; and he spoke probably according to the ideas of his time. But in modern estimation, there are several passages at which delicacy may justly take offence; and we can only say, that they may be termed rather jocularly coarse than seductive; and that they are atoned for by the admirable mixture of wit and argument by which, in others, the cause of true religion and virtue is supported and advanced.

"Fielding considered his works as an experiment in British literature; and therefore he chose to prefix a preliminary chapter to each book, explanatory of his own views, and of the rules attached to this mode of composition. Those critical introductions, which rather interrupt the course of the story, and the flow of the interest at the first perusal, are found, on a second or third, the most entertaining chapters of the whole work."

The publication of *Tom Jones* placed Fielding at the head of English novelists, but it seems to have been attended with little or no advantage to his fortune beyond the temporary relief afforded by the copy-money. His last work of importance was *Amelia*, which may be considered as a continuation of *Tom Jones;* but we have not the same sympathy for the ungrateful and dissolute conduct of Booth, as for the youthful, and on that account somewhat excusable, follies of Jones. The character of Amelia is said to have been drawn for Fielding's second wife; and if, as has been alleged, he put her forbearance to tests of the same kind, it must also be confessed that he has in some degree repaid her by the picture which he has drawn

of her purity, delicacy, and tenderness. *Amelia* was published in 1751 by Millar, who paid a thousand pounds for the copyright, and contrived to reimburse himself by an ingenious stratagem which he practised on the trade. In 1752, Fielding, unmoved by former failures, commenced a literary newspaper and review, to be published twice a week, which he entitled the *Covent-Garden Journal;* but although his ready pen, sharp wit, and classical attainments, highly fitted him for conducting a work of this kind, it was his failing to embroil himself in the party squabbles or literary feuds of the day; and on this occasion it was not long ere he involved himself in a quarrel with Dr Hill and other periodical writers, amongst whom we regret to mention Smollett, a man possessed of kindred genius, and second only to Fielding in that department of literature where both so eminently excelled. The warfare was of short duration, and neither party would derive honour from an inquiry into the cause or the conduct of hostilities.

Meanwhile Fielding's strength was fast decaying; a complication of disorders having terminated in a dropsical habit, which totally undermined his naturally robust constitution. But as the Duke of Newcastle, then prime minister, was desirous of receiving assistance from him in the formation of a plan for the prevention of secret robberies, and for improving the police of the metropolis, Fielding undertook, for the small consideration of L.600, to be paid by government, to extirpate several gangs of daring ruffians, who then infested London and its vicinity; and, though his health was thus impaired, he continued to superintend the conduct of his agents, to take evidence, and to make out commitments, until this great object was accomplished. The exertions which were thus rendered necessary, however, proved fatal to his exhausted frame, which was now suffering under dropsy, jaundice, and asthma. The Bath waters were tried, but in vain; and various modes of cure or alleviation were resorted to, though with little effect. As a last resource, therefore, his medical advisers recommended him to try the effect of a milder climate; and with this view he undertook a voyage to Lisbon, of which he has left a record, written with a hand trembling almost in its latest hour.[1] Fielding, however, reached that city alive, and remained there two months; but he was unable to continue his proposed literary labours. The hand of death was upon him; and in the beginning of October 1754 he terminated his earthly career, in the forty-eighth year of his age, leaving behind him a widow and four children. "Thus lived, and thus died," says Sir Walter Scott, "at a period of life when the world might have expected continued delight from his matured powers, the celebrated Henry Fielding, father of the English novel, and in his powers of strong and national humour, and forcible yet national expression of character, unapproached as yet even by his successful followers." (See Murphy's *Life and Genius of Fielding;* Chalmers' *Biog. Dict.*, art. *Fielding;* and, above all, Sir Walter Scott's *Prefatory Memoir*, in Ballantyne's *Novelist's Library.*) (J. B—E.)

FIERI FACIAS, in *Law*, a judicial writ issued on a judgment obtained for debt or damages in the king's courts, by which writ the sheriff is commanded to levy the debt and damages on the goods and chattels of the defendant.

FIESOLE. See FÆSULÆ.

FIFE, a military wind instrument, usually accompanied with the drum. It is sounded by a side-hole, like the German flute, and has a compass of two octaves, from D on fourth line of treble clef, up to D above in altissimo.

FIFESHIRE is situated between 56. 3. and 56. 25. N. Lat., and 2. 30. and 3. 50. W. Long., and bounded by the river and Firth of Tay on the north, by the German Ocean on the east, by the Firth of Forth on the south, and by parts of Kinross, Perth, and Clackmannan on the west. Its greatest length from west to east is about 41 miles, and its greatest breadth from north to south about 20 miles; its medium length from east to west is about 35 miles, and its medium breadth from north to south is nearly 13 miles. Its area is 459 square miles, or 293,760 imperial acres. Among the agricultural statistics collected by the Highland Society, and forwarded to the Board of Trade, the number of imperial acres in Fife to which the report is applicable amounts to 279,941. The most prominent features in Fifeshire, when viewed at a distance from the south, are the two Lomond hills in the middle of the county, the Bishop hills farther west, Largo Law farther east, and Normans Law and the Mount hill in the north-west and north of the county. The elevations of these hills have been ascertained by the ordnance surveyors to be above the level of the sea in feet as follows:—West Lomond, 1712·7; East Lomond, 1470·8; the highest Bishop hill, 1490·5; Largo Law, 953·0; Normans Law, 936·0; and the Mount hill, 730·3. Besides these there are numerous other elevations scattered over the county; and indeed it is everywhere found to present a pleasant variety of hill and valley, stretching in general from west to east, parallel to the Tay and the Forth. The principal valley is that through which the Eden flows, and is called the Howe of Fife, or Strath Eden. It lies to the north of the Lomond hills, which, with their western prolongation to the Cleish and Saline hills and their eastern continuation towards St Andrews, divide the county into the northern and southern portions. The valleys of the Leven and Ore are bounded by very gentle elevations, which in many places merge into the plain which may be said to slope from the central range to the Firth of Forth. The hills to the north of the Howe of Fife are a continuation of the Ochils, and are composed of an uninterrupted mass of trap rocks, flanked on either side by the lower beds of the old red sandstone

[1] Of his departure for Lisbon he has himself left the following melancholy record, in which his situation is painted a thousand times better than could have been done by any pen but his own: "On this day, Wednesday, June 26, 1754, the most melancholy sun I had ever beheld arose, and found me awake at my house at Fordhook. By the light of this sun, I was, in my own opinion, last to behold and take leave of some creatures on whom I doated with a mother-like fondness, guided by nature and passion, and uncured and unhardened by all the doctrine of that philosophical school, where I had learned to bear pains, and to despise death. In this situation, as I could not conquer nature, I submitted entirely to her, and she made as great a fool of me as she had ever done of any woman whatsoever; under pretence of giving me leave to enjoy, she drew me in to suffer, the company of my little ones during eight hours; and I doubt not whether in that time I did not undergo more than in all my distemper. At twelve precisely my coach was at the door, which was no sooner told me, than I kissed my children, and went into it with some little resolution. My wife, who behaved more like a heroine and philosopher, though at the same time the tenderest mother in the world, and my eldest daughter, followed me. Some friends went with us, others here took their leave; and I heard my behaviour applauded, with many murmurs and praises to which I well knew I had no title." (*Voyage to Lisbon*, p. 1.) This affecting passage remains a singular example of Fielding's natural strength of mind; and, indeed, the whole of the *Journey to Lisbon* shows that, whilst struggling at once with the depression and the irritability of disease, he could still exhibit a few flashes of that bright wit which used to set the world in a roar. "His perception of character, and power of describing it," says Sir Walter Scott, "had not forsaken him in those sad moments; for the master of the ship in which he sailed, the scolding landlady of the Isle of Wight, the military coxcomb who visits their vessel, are all portraits marked with the master-hand which traced Parson Adams and Squire Western."

formation. The Howe of Fife is entirely occupied by those upper strata of the old red sandstone to which Dr Anderson of Newburgh has given the name of the yellow sandstone. Mr Maclaren, in his work on the Geology of Fife and the Lothians, has named the same deposits the calciferous sandstone. The rocks of the southern division of Fifeshire chiefly belong to the coal formation of geologists, and form a portion of the great coal-field of the Forth. Here glance coal, or blind coal as it is sometimes called, is met with occasionally; slate coal, pitch coal, and cannel coal are occasionally found together in the same bed, and sometimes in separate strata in the same pit. From a charter dated in March 1291, it would appear that coal has been worked in this county for more than five centuries. In this charter William de Oberville grants liberty to the convent of Dunfermline to open a coal-pit in his lands of Pittencreiff. The principal coal-works at present are those in the parishes of Dunfermline, Beath, Dalgetty, Auchterderran, Ballingry, Dysart, Wemyss, and Markinch. In the southern division of the county three different limestone beds are met with, viz., the mountain or encrinitic limestone, the fresh-water limestone, and a stratum occurring in the midst of the coal measures which has received from geologists the name of the middle limestone. The first of these, the mountain limestone, is found in all directions around the outcrop of the coal strata. It is worked extensively at Charleston in the west of Fife, and at Fordel and Cults in the interior of the county. The fresh-water limestone is less extensively distributed, and is chiefly worked at Newbigging, near Burntisland, and used by the Carron Company in smelting iron.

Blackband ironstone also abounds in the Fife coal-fields, and for the last ten years it has formed one of the chief products of the county. It is raised by the Forth Iron Company at Oakly in the parish of Carnock, Steelend in Saline parish, and Cowden-Beath in the parish of Beath. There are also extensive mines at Lochgelly, Lumphinnans, Outh, Inzievar, and Killernie in the west of Fife, and at Winthank, near St Andrews, in the east of Fife. There are at present (1855) in full operation six smelting furnaces at Oakly, two at Lochgelly, and one at Lumphinnans. At Oakly alone there are more than 2000 workmen employed. The manufacture of malleable iron is now carried on to a considerable extent at the works of the Weardale Iron Company at Transy, near Dunfermline.

Sandstone abounds, and is quarried, in many places of the county, both within and without the bounds of the coal formation. It is sometimes of a fine grain and durable quality, is much used in the county for building, and is often exported for the purpose.

The trap rocks of Fifeshire may be divided into three portions, viz., that extending through the north of Fife, and forming the Ochils; 2dly, that extending through the central part of the county in a long series of hills from Saline to the neighbourhood of St Andrews; and, 3dly, that forming the masses of igneous origin protruding through the coal measures along the shores of the Forth, and rising to considerable elevations in the hilly district near Inverkeithing, and near Burntisland and Kinghorn, forming the Dunearn hill, Orrok hill, Glassmont hill, and the Bin, &c. Clinkstone forms generally the highest summit of the Ochils, greenstone and amygdaloid cap the Lomonds and the other hills of the central range, while basaltic rocks are chiefly perceptible in the detached masses of the trap which lie along the shores of the Forth.

In various parts of the county there are quarries in the trap rocks, from which the whinstone is taken for road metal. At Queensferry it is conveyed by sea to Newcastle and London for paving streets, and to various places on the English coast for the construction of harbours.

Pyrope, resembling the precious garnet, is sometimes found embedded in the trap tuff. At Ely they are gathered on the sea-beach, or picked out of the rocks, and sold to jewellers under the name of Ely rubies. Copper and zinc are also said to have been met with in several places, and lead has been worked in the Lomond hills. Marl is also often found in the lakes, and dug out in dry seasons for agricultural purposes.

There are now no mineral springs of any note in the county. The old ones have disappeared. The chalybeate spring on the east of Dysart is now little frequented for medicinal purposes, and the petroleum or ink Craig of Carnock is seldom visited even by the curious.

The only streams of any note in the county are the Leven and the Eden. The former issues from Lochleven in Kinross-shire, flows eastward from an elevation of about 362 feet above the sea level through a beautiful strath by Leslie, Balgonie, and Balfour, and after a course of about twelve miles falls into the Forth at the town of Leven. The latter river, the Eden, flows from Strathmiglo hills through the Howe of Fife by Cupar to near St Andrews, where it falls into the German Ocean, about 18 miles from its source.

The lakes in the county are numerous, though none of them are very large, such as those at Lindores, Kilconquhar, Kinghorn, Lochgelly, Camilla, Lochfittie, and Lochglow. The county once contained many more, which have been drained at great expense. Of these the most considerable were the lakes of Rossie and Lochore. Their beds are now used in raising valuable crops.

From the extensive drainage of the lakes and marshes, and the general improvement of the fields by cultivation, the climate within the last forty years may now be described as good. The harvests are early, and the snow does not lie long on the ground. As the direction of the hills is from east to west, vegetation is often checked in the spring months by the east winds which then prevail.

The soil above the trap rocks is in general of good quality, and where the subsoil is coal or sandstone it is in general of inferior quality. There is still a considerable portion of moor and moss in the Howe of Fife; and near Dunferm line and Lochgelly;—and between St Andrews and Ferryport, and from Leven on the Forth for many miles eastward, as well as in other places, there are considerable tracts covered with drift sand.

The number of farms or holdings in Fife is about 1175: of these 534 contain less than 100 acres and 641 more than 100 acres. The most improved implements of husbandry are everywhere in use. Threshing-mills, moved by horses, by water power, or by steam engines, are to be found on all farms.

The principal manures in use are farmyard dung, seaweed cast ashore and cut from the rocks, bone-dust, and guano. Lime and marl are also in use in certain localities.

All the farm crops common in Scotland are cultivated here, and a great portion of them on a large scale. According to the Highland Society's report to the Board of Trade upon the crop of 1854, the number of acres in tillage was made up thus: wheat 24,252$\frac{1}{4}$, barley 27,937$\frac{3}{4}$, oats 43,591$\frac{1}{4}$, rye 417$\frac{1}{4}$, bere or bigg 16$\frac{1}{4}$, beans 3894, pease 718$\frac{1}{4}$, vetches 1397$\frac{1}{2}$, turnips 27,961$\frac{3}{4}$, potatoes 14,486$\frac{3}{4}$, mangold 78, carrots 43, cabbage 7$\frac{1}{2}$, flax 1648$\frac{3}{4}$, turnip seed 58$\frac{3}{4}$, bare fallow 3547$\frac{1}{4}$. The number of acres in grass was made up thus: grass in the rotation of the farm 62,749$\frac{3}{4}$, permanent pasture 29,931$\frac{3}{4}$, irrigated meadows 1043$\frac{3}{4}$, sheep walks 10,378$\frac{1}{4}$. The acres in buildings, woods, &c., were made up of houses, roads, fences, &c., 5903$\frac{1}{4}$, waste 4330$\frac{3}{4}$, and woods 15,548.

The farm stock in Fife, according to the same statistics, is stated to consist of—horses 10,953, milch cows 8586, other cattle 22,371, calves 83,111, ewes, gimmers, and ewe hogs, 32,550, tups, wethers and wether hogs 33,866, swine 11,485.

The gross produce of the county was—wheat 697,252 bushels, barley 1,075,603, oats 1,656,467, bere or bigg 540, beans 111,952, turnips 405,445, potatoes 68,087.

Fifeshire.

The average produce per imperial acre in Fife was—wheat 28 bushels and 3 pecks, barley 38 bushels and 2 pecks, oats 38 bushels, bere or bigg 33 bushels and 1 peck, beans 28 bushels and 3 pecks, turnips 14 tons 10 cwts., potatoes 4 tons 14 cwts.

It will be found, from a comparison of the statistics of the Scots counties, as given by the Highland Society, that Fifeshire grows the greatest quantity of wheat and flax. It also grows the largest proportion of barley, its quantity being about one-seventh of the whole of that crop raised in Scotland.

The cattle of the Fife breed are not now in so much repute as formerly. The horses are much the same as those in use in all the lowlands of Scotland. A great many pigs have of late years been reared. Pigeons are still numerous, and the pigeon-houses have been estimated at not less than 300.

There is nothing remarkable in the zoology of Fifeshire. Rabbits abound in certain localities, and hares, pheasants, and partridges are plentiful. There are a few grouse and black cock, and fallow deer are occasionally seen. The flora of the country is nearly the same as that of Mid-Lothian. Extensive plantations have, since the commencement of this century, been made in almost every parish.

Grain is sold extensively in stock and sample at various weekly markets in Fife, of which the most considerable are at Kirkcaldy, Dunfermline, Cupar, and St Andrews; and these and every other town of any consequence have one or two yearly fairs for the sale of horses and cattle and agricultural produce, and for hiring farm servants and the purchase of agricultural implements, &c.

There are three *retteries* in the county for the manufacture of flax from the straw grown in the county, and about 150 hands are employed in this branch of business.

In 1850 this county possessed forty flax-spinning mills, which turned 52,344 spindles, had a moving steam-power equal to that of 786 horses, and a water-power equal to that of 567 horses. These mills employed 1038 males and 2942 females. Mr Fergus's great flax-spinning mill at Prinlaws, near Leslie, is the largest of the kind in Scotland. The flax power-loom mills in 1850 were reported to be only three in in number, to employ 194 looms, to have a steam-power equal to that of 42 horses, and to employ 54 males and 166 females.

The number of hand-loom linen weavers employed at present is estimated at 13,000. About 5000 more hands, chiefly women and children, are engaged by the weavers in the preparation of the yarns for them, and about 400 hands more are employed in the bleaching of these yarns at about twenty separate bleachfields, some of which are on a large scale.

Although a portion of the yarn spun is bleached and made into cloth in the county, a great portion is also exported to the Continent unbleached.

The nature of the cloth manufactured ranges from the coarsest sacking, and light, plain, and fancy dowlas, with ticks and checks, to the finest damask, and is extensively exported to all parts of the world. The fine table linens, damasks, and diapers, used by her Majesty's household at Balmoral and Buckingham Palace, were made in this county, and the reputation of the Fife manufacture of these articles, particularly at Dunfermline, was fully sustained at the London Exhibition in 1851. The other seats of this trade are Newburgh, Kingskettle, Dysart, Kirkcaldy, and Cupar. A considerable part of the linens manufactured in Fife is sent, before being sold, to be bleached in Perthshire and Forfarshire, and even to Ireland. Besides the linen cloth manufacture, the wool-trade, to a small extent, also exists in Fife. The process of spinning and weaving is carried on in two mills, moved by water with a power equal to that of 28 horses, which turn 1480 spindles, and drive 26 looms. These mills employ 25 males and 34 females.

Since the report upon the state of the linen trade was framed, from which the information above given was taken relative to the number of power-looms employed in the manufacture of cloth, it has been greatly increased, and they have been lately estimated at the number of 700.

Fifeshire.

Besides the trades and manufactures of the county, ship-building is carried on at Dysart, where there is a wet dock and a Morton's slip for raising vessels out of the water for repair, and at Burntisland, where there is a good harbour and dry dock. It is also carried on at other ports in the county. There are also extensive distilleries and breweries of ale, and several paper mills, brick and tile works, potteries, iron founderies, and tanneries, &c.

The shipping of the county is extensive, and its vessels trade to all parts of the world. The state of the harbours and the extent of their trade will be seen in the articles FORTH and TAY.

The banking business of the county is extensive; and is conducted in every town of any consequence by upwards of 30 branches of the principal Scots banks.

Private railways of wood and iron have been used for many years in transporting for several miles the produce of coal and lime quarries to the harbours where they are shipped. The most extensive of these railroads is that belonging to the Earl of Elgin. It proceeds from near Dunfermline to Charleston harbour, and has been for many years open to the public for the purpose of carrying passengers.

The great public trunk iron railway, from Burntisland on the Forth to Ferry-Port-on-Craig on the Tay, was opened throughout in the year 1848. The length of it between these two points is 36 miles. It has a branch from Thornton to Dunfermline of $15\frac{1}{4}$ miles, and from the station at Dunfermline this branch is continued to Stirling by the Stirling and Dunfermline Railway Company. From Ladybank station, on the trunk line, a branch is also carried for 16 miles to its junction with the Scottish Central Railway near Perth. It thus affords direct railway communication between Edinburgh and Dundee, and also to Dunfermline. A single line railway from Thornton station to Leven, 6 miles long, was attached to it in 1854; and a single line railway, from Leuchars station to St Andrews, $5\frac{3}{4}$ miles long, was attached to it in 1852. Bills are at present (1855) before parliament for forming a railway 14 miles long from Ladybank station to Kinross by Auchtermuchty, and to form a railway from Leven to Kilconquhar, in continuation of that from Thornton station.

The Edinburgh and Northern Railway Company, which formed the first of these railways, is now united with the Granton Railway Company, and the united company has assumed the name of the Edinburgh, Perth, and Dundee Railway Company.

It has acquired stations in Edinburgh and Leith, and at Trinity and Granton, in Mid-Lothian, and formed or completed railways between all these stations. It has also acquired the ferries between Granton and Burntisland, and between Ferry-Port-on-Craig in Fife and Broughty in Forfarshire. It has also formed branch railways from the trunk line to Pettycur and Kirkcaldy harbours, and purchased the harbours of Kinghorn and Pettycur, Ferryport, and Broughty, and extensive properties at all the harbours and stations where necessary for the undertaking.

The capital expended on these works and purchases, and their appendages, including the plant of the railway, &c., and interest, amounted on 31st January 1855 to L.3,277,000, of which L.1,661,000 has been paid by the shareholders, and L.1,616,000 has been borrowed on debenture or from banks or otherwise. The revenue arising from the traffic amounted for the year ending at the same date to L.155,453, 11s. 3d., which was made up as follows:—For 1,216,168 passengers, L.65,885, 10s. 2d.; for 292,794 tons of goods,

231,866 tons of coals, 10,359 cattle, 29,981 sheep, 2353 pigs, L.87,280, 15s.; and for miscellaneous articles, L.2287; 6s. 1d. The working expenses for the same year amounted to about L.88,613, leaving a surplus for the payment of interest, and towards the liquidation of the debts of the company, of L.66,840, 11s. 3d.

The value of the different kinds of stock from which the railway was made is according to the stock share list of 13th February 1855, as follows:—Original share, L.25 paid, L.5 now consolidated into capital stock; Granton preference, 4 per cent. do., L.20 paid, L.13, 15s.; preference, 4 per cent. do., L.5 paid, L.3, 2s. 6d.

The capital expended by the St Andrews Railway Company on the formation of that line was L.26,000. It is supplied with plant and worked by the Edinburgh, Perth, and Dundee Railway Company. The revenue for the year ending 31st January 1855 for 66,403 passengers was L.1826, 12s. 9d.; for 16,651 tons of goods, 9970 tons of coal, 1789 cattle, 2528 sheep, and 229 pigs, was L.1355, 3s. 11d.; together, L.3181, 16s. 8d.

The capital of the company which formed the railway from Thornton to Leven is L.28,000. It is supplied with plant and worked by the Edinburgh, Perth, and Dundee Railway Company, and the revenue and traffic corresponds with the capital expended, so far as it has yet been ascertained.

The great turnpike roads of the county, which are made and maintained by revenue collected at toll-bars, and the cross and bye roads by a tax on householders, on carriages, and on each plough-gate of land, are under the charge of parliamentary trustees, consisting of justices of the peace and commissioners of supply for the county, &c. The accounts of these trustees are printed and published annually. The only pontage or bridge tax levied in the county is that at the bridge over the Leven near the town of that name.

In all parts of the county the dwellings of the nobility, gentry, and agricultural labourers, and those of the other working classes, have been extensively renovated and rebuilt, and a great number of new houses and villages have been erected within the last fifty years.

The most ancient and celebrated buildings in the county are the tower of St Regulus, Cathedral, and Castle, at St Andrews, the Abbeys of Dunfermline and Inchcolm, the Palace of Falkland, the Castle of Ravenscraig, and Macduff's castle at East Wemyss. There are many others of less note.

The county contains thirteen royal burghs, with parliamentary privileges. St Andrews, Cupar, Anstruther Easter and Wester, Pittenweem, Crail, and Kilrenny, send one member to parliament; Kirkcaldy, Dysart, Burntisland, and Kinghorn send another; and Dunfermline and Inverkeithing join with Stirling, Queensferry, and Culross in electing a member to represent them.

The sixty-three parishes within the county are represented by another member.

These parishes form, for ecclesiastical purposes, the Synod of Fife, which is divided into four presbyteries, viz., the presbyteries of Kirkcaldy, Cupar, Dunfermline, and St Andrews.

Before these ecclesiastical divisions of the county (or kingdom of Fife, as it is sometimes called) were in general use for secular purposes, it was split up into petty shires, such as Lochoreshire, Dunfermlineshire, Gaitmilkshire or Kinglassie, Wemyss-shire, Kingornshire, &c., &c. It was also divided into regalities, constabularies, and baronies. A map showing these ancient divisions is at present in progress of construction by a learned antiquary, from the information contained in ancient charters.

The regality of stewartry of Fife forfeited to the crown at the condemnation of Murdo Earl of Fife, contained lands lying in no less than nineteen of the modern parishes: the other regalities were not so extensive.

The courts in the county for the trial of crime and civil suits consist—1. of the burgh courts, the magistrates of which have jurisdiction within their respective royalties or burgh territory only; 2. of the sheriffs' ordinary courts, which are held at Cupar and Dunfermline, and circuit small debt courts, which are held periodically at Kirkcaldy, Leven, Colinsburgh, St Andrews, Newburgh, and Auchtermuchty; 3. of the justice of peace courts for deciding claims for small debts and petty offences, &c.

The jails of the county are those of Cupar and Dunfermline.

The educational establishments are the parish schools and schools supported by private exertions in considerable number in every populous locality.

The university of St Andrews, and the schools endowed by Dr Bell, are noticed under St Andrews; and the schools endowed by the late Mr Robert Philp, merchant in Kirkcaldy, under Kirkcaldy.

From the population returns in 1851, it appears that the number of schools in Fife is 285, the children attending 23,145; the number of the Sabbath-schools is 183, and the number of children attending 14,753.

The number of places of worship is 199, and the number of attendants at public worship on the morning of Sunday the 30th of March 1851 were 50,622. Of these 21,274 belong to the Established Church, 12,728 to the United Presbyterian Church, and 13,083 to the Free Church.

The population of the county in 1801 was 93,743; in 1811, 101,272; in 1821 it was 114,550; in 1831 it was 128,800; in 1841, 140,140; and in 1851, 153,546.

FIFTH-MONARCHY-MEN, a sect of English fanatics during the Protectorate, who supported Cromwell's government, which they regarded as the commencement of the fifth monarchy, or that which should succeed to the Assyrian, the Persian, the Grecian, and the Roman, and in which Christ should reign with the saints on earth for a thousand years. See Britain, vol. v., p. 416.

FIGEAC, a town of France, capital of a cognominal arrondissement in the department of Lot, situated on the right bank of the Selle, 32 miles N.E. of Cahors. It is enclosed by an amphitheatre of wooded and vine-clad hills, but the town itself is ill built, and the streets are narrow and dirty. Many of the buildings are remarkable for their antique style. It was formerly surrounded by ramparts and ditches, but these were demolished in 1622, though remains of them still exist. Among the public edifices worthy of notice are the abbey church of St Sauveur, the church of Notre Dame du Puy, the Château de la Baleine. At the S. and W. extremities of the town are two obelisks called *les aiguilles*, octagonal in form, and upwards of 50 feet in height: they were used in former times as fire beacons to guide travellers by night. Champollion the archæologist was born here in 1790, and an obelisk has been erected to his memory near the river. Pop. (1851) 7197.

FIGUEIRA, a town of Portugal, province of Beira, stands on the north bank of the estuary of the Mondego, 24 miles W.S.W. of Coimbra, of which it is the port. It is a favourite bathing-place, and has an extensive export trade in salt, wine, oil, and fruits. The harbour is difficult of access for large vessels. Pop. 6500.

FIGUERAS, a frontier town of Spain, province of Gerona, and 20 miles W.N.W. of the town of that name. It is a straggling town, situated in a rich plain of olives and rice. The citadel is an irregular pentagonal structure on the principles of Vauban, and is considered one of the strongest fortresses in Europe. It was built by Ferdinand VI., and has accommodation, magazines, &c., for 16,000 men. The buildings inside the walls are all bomb-proof, and the natural adaptation of its situation has been so taken advantage of that trenches can scarcely be opened on any side, the ground being everywhere rocky. It has, however, been several times captured; as by the French in 1808, 1811, and 1823. Figueras has manufactures of leather and paper, and some trade with France. Pop. 8352.

FIGURE OF THE EARTH.

SECTION I.

INTRODUCTION.

The determination of the figure and dimensions of the earth is a problem of very great importance in astronomy, inasmuch as it is in reference to the earth's diameter that the distances of the planets from the sun and from each other are estimated. It is also a problem of very great interest and curiosity; and has accordingly attracted the attention of mankind since the earliest dawn of civilization.

There are two points of view under which this great question may be considered. The figure of the earth may be regarded as a fact to be determined by investigation and experience, like any other phenomenon or law of nature; in which case it is necessary to find, by the actual measurement and comparison of different portions of the terrestrial surface, the nature of its curvature, and the magnitude of its diameters. Under the second point of view, the question is one of pure theory. The earth may be regarded as a congeries of material particles, attracting each other with forces reciprocally proportional to their mutual distances, and endowed with a rotatory motion about a fixed axis; and the problem is to determine the form the whole mass would assume in virtue of the attractive and centrifugal forces by which the particles are impelled. Viewed in this light, the actual figure of the earth becomes one of the series of consequences resulting from the universal gravitation of matter, and depending on the same laws which regulate its motion in its orbit about the sun.

It would be a waste of time to inquire what were the notions of the figure of the earth which were or might have been entertained by its earliest and most ignorant inhabitants. A very slight attention to the most common phenomena renders the fact of its general roundness almost palpable to the senses. The uniform level appearance of the sensible horizon in every situation in which a spectator can be placed,—the depression of the circumpolar stars as he advances toward the south, and their elevation as he proceeds in a contrary direction,—the disappearance of a ship standing out to sea,—the projection of the earth as seen in a lunar eclipse,—and a number of other familiar appearances,—put the globular figure of our planet beyond all manner of doubt. Reasoning from such appearances, the earliest astronomers universally regarded the earth as a sphere; and their attention was solely directed, in their various measurements and computations, to ascertain its dimensions. Modern science has discovered that its figure deviates slightly from that of a sphere, being compressed or flattened at the extremities of its axis of rotation; and the object of the astronomer, at the present time, is to determine not only its dimensions, but also the exact amount of its compression.

Attempts to estimate the magnitude of the earth were made at a very early date; for Aristotle relates that the mathematicians prior to his time had found the circumference to be 400,000 stadia. But Eratosthenes appears to have been the first who entertained an accurate idea of the principles on which the determination of the figure of the earth really depends, and attempted to reduce these principles to practice. His results, in consequence of the imperfect data from which they were deduced, were very inaccurate; but his method is the same as that which is followed at the present day, depending, in fact, on the comparison of a line actually measured on the surface of the earth with the corresponding celestial arc. He had remarked, or been informed, that at Syene in Upper Egypt, on the day of the summer solstice, at noon, objects cast no shadows; whence he concluded that the sun was exactly in the zenith at mid-day. On the same day at Alexandria he observed the sun's meridional distance from the zenith to be 7° 12′, or a fiftieth part of the circumference. Then, assuming Syene to be exactly under the meridian of Alexandria (the error in this assumption was about 3°), and the distance between the two places, measured in a straight line, to be 5000 stadia, he had $5000 \times 50 = 250{,}000$ stadia for the whole circumference of the earth. It is easy to see how very imperfect this operation must have been. Without mentioning smaller errors, the neglect of the solar diameter would alone occasion an uncertainty as to the sun's declination, and consequently as to the length of the celestial arc, amounting to half a degree on the observation at Syene; and there is no reason to suppose that that at Alexandria was more exact. The terrestrial distance between the two places was assumed on equally, or probably still more loose and inaccurate determinations.

The next attempt to ascertain the dimensions of the earth was made by Posidonius. This astronomer adopted a method which differed from that of Eratosthenes only in determining the celestial arc by means of the altitude of a star, instead of the sun's zenith distance. At Rhodes the bright star Canopus, when on the meridian, barely appears above the horizon. At Alexandria the same star was observed to have a meridional altitude of a quarter of a sign, or seven and a half degrees, which, therefore, was the celestial arc intercepted between the zenith of Alexandria and Rhodes. The terrestrial distance between the two places was estimated, like that between Alexandria and Syene, at 5000 stadia, and they were both supposed to be under the same meridian. Hence, since seven and a half degrees is the forty-eighth of the circumference, we have $5000 \times 48 = 240{,}000$ stadia, for the whole circumference of the globe.

It is impossible to form any correct opinion of the degree of approximation attained in these ancient measures, as the length of the stadium is not known with any certainty. That it varied in different places, and at different times, is sufficiently obvious from the statement of Ptolemy, who, in his work on geography, assigns the length of the degree at 500 stadia, and consequently the whole circumference at 180,000, differing from the determination of Posidonius in the proportion of three to four, and still more from that of Eratosthenes. Ptolemy remarked that it was not necessary that the line measured should lie exactly in the meridian: it was sufficient to know its inclination to the meridian, or the azimuthal angle, together with the latitudes of its extreme points, in order to compare it with the meridional arc. The determination of the azimuth is, however, an operation of considerable difficulty; and Ptolemy has given no details of the method by which he proposed to estimate it. He has been equally silent in respect of the means by which the mean length of a degree was ascertained to be 500 stadia, so that the result which he has recorded is still less satisfactory than those of the two more ancient astronomers.

The active curiosity of the Arabians, which was exerted so successfully in promoting practical astronomy, did not

[1] Contributed by Thomas Galloway, 1836; and brought up to the present date (1855) by C. P. S.—*Ed.*

overlook the measure of the earth. The Caliph Almamoun, who began his reign in the year 814, ordered a company of astronomers to measure a degree on the level plain of Mesopotamia. Dividing themselves into two parties, the one proceeded northward, and the other southward, in the direction of the meridian, through a degree of latitude, and measured with rods the itinerary distance as they proceeded. The perfect agreement of their conclusion with that of Ptolemy throws it open to great suspicion; and when it is considered that their operation was repeated at a different place, with exactly the same result, there can be no doubt that they blindly adopted the statement of the Greek astronomer, either from inability to execute the task assigned to them, or because they had no confidence in their own determination.

From the time of Almamoun, the problem of determining the dimensions of the earth was neglected, till the revival of astronomy with general learning in Europe. The first attempt to solve it was made by Fernel, who, about the middle of the sixteenth century, measured the distance from Paris to Amiens along the high road, by observing the number of revolutions made by his coach-wheel in the journey between these two cities. Supposing them to be under the same meridian, which is nearly true, and having ascertained the difference of their latitudes, Fernel found by this means the length of the degree to be 57,070 French toises, or about 364,960 English feet. A degree was measured long afterwards at the same place by Lacaille, in a far more adequate and scientific manner, and he found it to be 57,074 toises. This agreement is rendered less extraordinary by the circumstance that the toise of Fernel was not exactly of the same length as that of Lacaille. After all, it must be allowed that Fernel made a fortunate guess. (Delambre, *Astronomie*, tom. iii. chap. xxxv.)

But the first who had the merit of attempting to execute the geodetic operations that are indispensably necessary to effect the accurate measurement of a long line on the surface of the earth, was Willebrord Snell, a native of Holland, and a teacher of mathematics. Having established a chain of triangles between Alkmaer and Bergen-op-Zoom, and observed the angles of each triangle by means of a quadrant of five and a half feet radius, he measured a base on the frozen surface of the meadows between Leyden and the village of Soeterwoud, and determined the distance between the two places by trigonometrical computation. The length of the degree which he found was 28,500 Rynland perches, or about 55,020 toises, which is about 2050 toises too small. This result was published by Muschenbroek, who in fact revised or calculated the observations from the original papers a century after the death of Snell.

Norwood in the year 1635 attempted to measure a degree in England nearly in the same manner as Fernel. He measured the distance between London and York along the public road, taking the bearings and reducing the direction to the meridian in a rough way. The difference of latitudes he found by observations of the solstice to be 2° 28′, and thence concluded the length of the degree to be 367,176 English feet. Like the measurement of Fernel, this has been found to be a much nearer approximation than the method employed would have led us to expect.

The application of the telescope to circular instruments gave a far higher degree of precision to geodetic operations. Picard, to whom practical astronomy is indebted for this capital improvement, was the first who measured an arc of the meridian with such precautions and care as the delicate nature of the operation requires. He twice measured with wooden perches a base of nearly seven English miles in length; and observed the angles of his triangles with a quadrant, having a telescope adapted to it with cross wires in its focus. He even calculated the error produced by the instrument being placed out of the centre of the station, and determined the zenith distance of a star in the constellation Cassiopeia with a sector, for the purpose of obtaining the differences of latitude. The distance between Amiens and Malvoisine was found to be 78,850 toises, and the difference of latitude 1° 22′ 55″, whence the result gave for the degree at Amiens 57,060 toises; but as the aberration and nutation were unknown at that time, and the refraction was not taken into account,—causes of error to which it is indispensably necessary to have regard,—a determination which agrees so nearly with the results of recent measures could only have arisen from a fortunate compensation of errors. In fact, his toise was somewhat shorter than that which has since been adopted as the standard; and the error occasioned by this circumstance nearly compensated that which was committed in determining the celestial arc, so that in recalculating all the observations, the degree is found to be very nearly the same as was found by Picard.

Hitherto geodetic operations had been confined to the determination of the magnitude of the earth; but a discovery made by Richer turned the attention of mathematicians to its deviation from the spherical form. This astronomer having been sent, by the Academy of Sciences of Paris, to the island of Cayenne in South America, for the purpose of determining the amount of terrestrial refraction and other astronomical objects, observed that his clock, which had been regulated at Paris to beat seconds, lost about two minutes and a half daily at Cayenne, and that, in order to bring it to measure mean solar time, it was necessary to shorten the pendulum by more than a line. This fact, which appeared exceedingly curious, and was scarcely credited till it had been confirmed by the subsequent observations of Varin and Deshayes, was first explained in the third book of the Principia, by Newton, who showed that it could only be referred to a diminution of gravity arising from one of two causes—a protuberance of the equatorial parts of the earth, and consequent increase of the distance from the centre, or from the counteracting effect of the centrifugal force, occasioned by the rotation of the earth. The former could not, on any reasonable supposition regarding the figure of the earth, be regarded as adequate to produce the effect; but the latter, which would produce a retardation of the pendulum at Cayenne in the ratio of the square of the sine of 6° to that of 49° (the respective latitudes of Cayenne and Paris), might amount to 1·46 seconds. This was the first direct proof that had been obtained of the diurnal rotation of the earth.

From this time the exact determination of the figure of the earth began to assume a degree of importance which had not formerly attached to it. The centrifugal force arising from the diurnal rotation completely set aside the idea of perfect sphericity. Newton, assuming that the earth had been originally fluid, and supposing its density to be the same throughout the whole mass, and supposing moreover that its constituent molecules attract one another in proportion to the inverse square of the distance, demonstrated that it would assume, in consequence of the rotation, the form of a spheroid flattened at the poles; and that the proportion of its equatorial to its polar axis would be 230 to 231. But the supposition of the equal density of the earth is obviously very improbable, and consequently the ratio of the equatorial and polar diameters must be different from that now mentioned. Newton erroneously concluded that if the density is greater in the interior of the earth than at the centre, the compression would be greater than in the case of a spheroid of equal den-

sity. This mistake was pointed out by Huygens, who, in order to determine the amount of the compression from theory, reasoned in this way. Suppose two tubes to be united at the centre of the earth, forming a right angle with each other at that point, and extending to the surface, one in the plane of the equator, and the other along the polar axis, and filled with a homogeneous fluid. Now the fluid contained in the polar branch exerts a pressure on the centre equal to the whole of its weight, while the pressure of that in the other tube will be diminished by the centrifugal force. The second column, therefore, if of the same length, will be less heavy than the first; and in order to restore the equilibrium, it is necessary that the equatorial tube shall have gained as much in length as it has lost in weight through the effect of rotation. Hence the sea in the equatorial regions must be higher, or at a greater distance from the centre, than the polar sea, and consequently the earth must have a flattened form. Calculating from the supposition that the density increases regularly from the surface to the centre, where it is infinite, Huygens found the ratio of the diameters to be that of 578 to 579. This investigation is given in his work *De Causa Gravitatis*, published in 1690.

The theoretical determinations of the form of the earth by Newton and Huygens were at variance with the results of geodetic operations that had been carried on in France under the superintendence of the first Cassini, from 1680 till 1716, for the purpose of making a geometrical survey of that country. Cassini found the degree of the meridian to the south of Paris to be 57,092 toises, while on the north of that city it was only 56,960 toises. This result led to the conclusion that the earth is a protracted spheroid, or elongated at the poles; a conclusion entirely inconsistent with the principles of hydrostatic equilibrium, and the deductions of Newton and Huygens. The question, however, was of too great importance to astronomy to be allowed to remain undecided. Accordingly, the Academy of Sciences of Paris determined to apply a decisive test, by the measurement of arcs at a great distance from each other. For this purpose some of the most distinguished members of their body undertook the measurement of two meridional arcs, one in the neighbourhood of the equator, and the other in a high latitude. In 1735 Godin, Bouguer, and La Condamine, proceeded to Peru, where they were joined by two Spanish officers, Don Georges Juan and Antonio d'Ulloa, and, after ten years of laborious exertion, they measured an arc of above three degrees, between the parallels of 2′ 31″ north and 3° 4′ 32″ south latitude. The other party, consisting of Maupertuis, Clairaut, Camus, Lemonnier, Outhier, and Celsius, were in some respects more fortunate, inasmuch as they completed the measurement of an arc near the polar circle, of 57 minutes, and returned to Europe within sixteen months from the period of their departure.

The measurement of Bouguer was executed with great care; and, on account of the locality (the extremities being on different sides of the equator), as well as the excellent manner in which all the details were conducted, it has always been regarded as a most valuable determination. The original base was measured twice, and the difference between the two measures was scarcely two and a half inches. A second base of 5259 toises was measured with the most scrupulous attention by Bouguer, Condamine, and Ulloa, near the southern extremity of the arc, and the result differed less than a toise from the length calculated from the triangles. The latitudes at the two extremities of the arc were determined by simultaneous observations of the same star with zenith sectors. In fact, as the nutation of the earth's axis was then unknown, and as a considerable time necessarily elapsed before a large instrument could be transported from one extremity of the arc to the other, the results of successive observations with a single instrument presented little accordance. By the simultaneous observations, the greatest deviation from the mean did not exceed three or four seconds.

In consequence of a misunderstanding that unhappily sprung up among the principal persons engaged in this memorable expedition, their operations were conducted separately, and we have accordingly three independent results, but all agreeing very nearly with each other. The first is that of Bouguer, who found, after the various reductions, the length of the degree of the meridian at the equator, and reduced to the level of the sea, to be 56,753 toises. Condamine found 56,749 toises, and the Spanish officers 56,768 toises.

The party of Maupertuis, though their labours were sooner completed, had also to contend with very great difficulties. At their departure from France they had hoped to find a sufficient number of stations among the small islands situated in the Gulf of Bothnia; but on their arrival it was found impracticable to carry on a triangulation among the islands, consequently they were obliged to penetrate into the forests of Lapland. They commenced their operations at Tornea, a city situated on the mainland near the extremity of the gulf, and which formed the southern extremity of their arc. From this place they carried a chain of triangles northward to the mountain of Kittis, lat. 66° 48′ 22″. Here they commenced the observations of latitude by observing the distance of their zenith from the star δ Draconis; and having obtained a sufficient number of observations, they returned to Tornea, to determine the latitude of their station there in the same manner. At Tornea they observed not only the star δ Draconis, but also α Draconis; and some doubt having arisen respecting the accuracy of the determination at Kittis, they again repaired to that station, to observe the last star there also. The amplitude of the celestial arc was found, by taking the mean of the observations, to be 57 29″·6.

It now remained only to measure a base, and thereby determine the terrestrial distance between Tornea and Kittis. This was accomplished on the frozen surface of the river, by two parties who measured separately, and the difference between their results amounted only to about four inches. From this it resulted that the terrestrial arc between Tornea and Kittis was 55,023 toises, giving 57,422 toises to the degree, and consequently exceeding the degree measured by Picard in France by 362 toises.

As all these determinations concurred in proving that the degrees of the meridian increase very sensibly in length from the equator to the high latitudes, no doubt could any longer be entertained that the earth is compressed at the poles. The operations of the two Cassinis in France alone gave results leading to an opposite conclusion; and it therefore became desirable to ascertain the cause of the anomaly. For this purpose Maupertuis and his former associates undertook the verification of Picard's operations; and it resulted from the remeasurement of the arc between Paris and Amiens that the degree was equal to 57,183 toises. But a more extensive series of operations was undertaken some time after by Cassini de Thury (the third of that name) and Lacaille. With a view to determine more accurately the variation of the degree along the French meridian, they divided the whole arc between Dunkirk and Collioure into four partial arcs, embracing about 2° each, by observing the latitudes at five different stations. While engaged in this measurement, they discovered that the toise which had been used by Picard was shorter by about a thousandth part of the whole than that

which formed their standard, and that his final results were accordingly too great by about a thousandth part. They also found the mean length of a degree between Paris and Bourges to be 57,071 toises; between Bourges and Rhodez only 57,040 toises; and between Rhodez and Perpignan 57,048 toises; thus showing on the whole a very sensible diminution as we proceed towards the south. The last portion which they examined was that between Paris and Dunkirk; and after a very careful determination of the latitudes, and the measurement of a base of verification near Dunkirk, they found the degree to be 57,084 toises, greater than any of the former, as ought to be the case on the hypothesis of a polar compression.

Another important operation was likewise undertaken by Cassini and Lacaille, namely, the measurement of a degree of a parallel of latitude. The place they selected was near the mouths of the Rhone, under the forty-third parallel. One of the observers took his station on the mountain Sainte Victoire, near Aix, and the other on Saint Clair, near Cette. On the tower of the church of Sainte Marie, a village situated between the two stations, a signal was made by firing a quantity of loose gunpowder; and the instant of the flash was noted by each of the observers. The difference of sidereal time thus determined was 7 minutes 33·25 seconds, corresponding to a difference of meridians of 1° 53′ 19″. The distance between the two stations, which was ascertained by triangulation, being reduced to the distance on the parallel intercepted between the two meridians (at the latitude of 43°½), was found to be 78,599·6 toises, whence the length of the degree was computed to be 41,618 toises. This exceeded by about 260 toises the length of a degree of the same parallel computed on the hypothesis of the earth's being a perfect sphere. The details of all these operations are given in the *Meridienne de Paris Vérifiée.*

About the middle of the last century several arcs of meridian were measured in various countries, which, though of inferior importance in comparison of the more extensive surveys which have since been undertaken, are nevertheless deserving of enumeration. In 1751 Lacaille measured an arc at the Cape of Good Hope, whither he had gone for the purpose of determining the lunar parallax, and making other astronomical observations. At the latitude of 33° 18½′ he found the degree of the meridian to be 57,037 toises. This result was nearly the same as had been obtained in France, 10° farther from the equator; and clearly proved either the existence of great local irregularities in the form of the earth, or the dissimilarity of the two terrestrial hemispheres. As theory recognised no such abnormal condition of figure, and on the other hand, Lacaille's observations, all the details of which had been preserved, appeared to have been carefully made and correctly computed, the result which they gave was for some generations a very *vexata quæstio* amongst all geodesists. After the lapse, however, of nearly a century, the arc has been lately remeasured under the auspices of the British government, with all the modern improved means and appliances; and an approximate calculation of the observations shows, that the greater part of Lacaille's anomaly was produced by *mountain attraction* on his plumb-line. (1855.)

In 1751 the measurement of a terrestrial arc was undertaken in the Roman states by the Jesuits Maire and Boscovich. It extended nearly two degrees, between Rome and Rimini, and it was found that the degree of meridian between these parallels, namely, 42° and 44°, contained 56,973 toises. The details are given at length by Boscovich, in a work of great elegance, and entitled *De Litteraria Expeditione per Pontificiam ditionem*, &c. Romæ, 1755.

Liesganig, a Jesuit, in 1762 also executed two measures of a meridional degree, one in Hungary and the other in the Austrian states; but it has been shown by Baron Zach, in his *Correspondence Astronomique*, vol. vii. that the results merit no confidence, and, in fact, would lead to certain error if employed as elements in determining the figure of the earth.

About the same time, in 1764, an arc of meridian was measured in North America, on the peninsula between the Chesapeake and Delaware bays, by two Englishmen, Charles Mason and Jeremiah Dixon. They employed no triangulation, but measured the line with deal rods along the whole extent of the arc, the mean latitude of which was 39° 12′. Their rods were afterwards compared with the five-feet brass rods made by Bird. The latitudes were determined with a zenith sector. The length of the degree, after the necessary corrections and reductions were made, was found to be 60,625 English fathoms, or 56,888 toises. There is no doubt that great care was bestowed on this operation; it is, however, easy to see that the measurement of so long a line by means of rods is liable to many causes of error from which the method of triangulation is exempt.

In 1762 Beccaria undertook to measure a degree in the plains of Piedmont. He found the degree of the meridian at the latitude of 44° 44′ to contain 57,468 toises; but great uncertainty remained respecting the correctness of the latitudes, the extreme points of the arc being in the near neighbourhood of immense ranges of mountains, which could not fail to produce a very considerable deviation of the plumb line. It was supposed that as both ends of the arc were terminated by mountain ranges, whereas Boscovich's arc had been carried across the Appennines and terminated at the sea coast, the errors of the two measures occasioned by the local attraction, being of opposite kinds, would neutralize each other, and give a correct mean result.

Amidst the rapid advances of mathematical science towards the end of last century, the determination of the figure of the earth was not overlooked. In the year 1783 a memorial was presented to the British government by Cassini de Thury, stating the important advantages that would result to astronomy and navigation, from having the difference of longitude of the Greenwich and Paris observatories determined by a geodetic measurement. Fortunately this proposal was agreed to. The English operations were placed under the superintendence of General Roy, who to active and indefatigable zeal united great skill and experience in practical astronomy and surveying. In the summer of 1784 a base of rather more than five miles was measured on Hounslow Heath. In the measurement of this base, deal rods were at first employed; but as these were found to warp, and be affected with the variations of the hygrometrical state of the atmosphere, glass tubes were substituted; and in 1791 the same base was measured with a steel chain carefully made by Ramsden, yet the difference from the former measure was found to be only three inches. The mean result was 27,404·2 feet reduced to the level of the sea, and the scale being taken at the temperature of 62° of Fahrenheit. A chain of 32 triangles, in connection with this base, extended over the country to Dover and Hastings; and two more, stretching across the channel, connected them with the French signals on the opposite side. The instruments employed in this survey were of the most excellent description, and far superior to any that had ever been employed in similar operations. The angles of each triangle were measured by a large theodolite constructed by Ramsden; and it was this splendid instrument that first exhibited the *spherical excess*, or the minute quantity by which, on ac-

count of the sphericity of the earth, the sum of the three angles of a triangle on the earth's surface exceeds 180°.

The French part of this great operation was conducted with equal ability by Cassini (the fourth of that name), Mechain, and Delambre. The angles were measured with the repeating circle of Borda; an instrument of a very different description from the theodolite, but which in geodetic operations may fairly be allowed to give, if not equally, at least sufficiently correct results, while in practice it is much more commodious. The result of the combined measures showed the meridian of Paris to be 2° 19′ 51″ east of Greenwich, or 9″ less than had been determined by Dr Maskelyne.

Soon after this time a series of geodetic measurements was commenced both in France and England, which, in point of extent, as well as minute accuracy, far surpassed all the operations which had yet been undertaken with a view to determine the figure of the earth. In 1791 the National Convention of France having agreed to remodel the system of weights and measures, determined to adopt a standard taken from nature, which might be universally applicable in all countries, and capable of being restored in any future age, if by accident it should happen to be lost. Two such standards were proposed,—namely, the length of the pendulum, which makes a given number of vibrations in a given latitude; and the quadrant of the terrestrial meridian. Of these the pendulum is by far the most easy to be determined; but it was objected, that as the length of the pendulum varies at different latitudes, and also depends in some degree on the geological character of the country where it is measured, its length, if it should happen to be lost, could not be recovered, without knowing the precise place at which it had formerly been determined. The length of the quadrant of the meridian is, however, invariable, and, if the earth is a regular spheroid of revolution, must be the same at all places. Accordingly, the Convention chose the ten millionth part of the meridian from the equator to the pole as the unit of their new scale; and in order that this unit might be determined with the greatest possible precision, it was resolved to remeasure the arc of the meridian of Paris, and to extend it from Dunkirk to Barcelona, a distance comprehending altogether an arc of about nine degrees. The practical execution of this undertaking was confided to two astronomers of distinguished ability, Delambre and Mechain, by whom the requisite operations were carried on during the years 1792, 1793, and 1794, amidst all the dangers and difficulties arising from the disorganized state of the country, with a resolution and courage of which the annals of science afford few examples. The triangles amounted to 115 in number. Each of the three angles of every triangle was separately observed with the repeating circle. The different observations, with the original registers and remarks of the observers, were compared by commissioners, among whom were some of the ablest men in France. A form was drawn up, after which all the calculations were made. The calculations of the triangles, as well as of the azimuths, were examined by Tralles, Van Swinden, Legendre, and Delambre himself. The triangles were connected in the neighbourhood of Paris with a base of upwards of seven miles in length, being 6075·9 toises, at the temperature of 16¼ centigrade, or 61¼ of Fahrenheit. A base of verification of 6006·25 toises was measured by Mechain, near Perpignan, at the southern extremity of the arc; and the measured length was found to differ by less than a foot from the length deduced by calculation from the first base, though the distance was more than 436 miles. A line of this length, measured with extreme precision, is obviously quite sufficient to enable us to infer, with all the requisite exactness, the length of the quadrantal arc; but the French astronomers resolved to extend the triangulation still farther. Accordingly, Mechain repaired again to Spain, and in the year 1805 continued the chain of triangles from Barcelona to Tortosa, on the coast of the Mediterranean. At this place his labours were prematurely terminated by an epidemic fever The prolongation of the arc was, however, committed to two philosophers of distinguished reputation, Biot and Arago. An immense triangle, one of the sides of which exceeded 100 miles, connected the coast of Valentia with the island of Iviza, which was joined by another triangle with Formentera, distant no less than 12° 22′ 13″·39 from Dunkirk, the northern extremity of the arc. The result of the whole gave a value of the quadrantal arc, differing somewhat from that determined by Delambre and Mechain, but so little that the length of the metre would be scarcely affected by four times the millionth part of itself. The details of this magnificent operation are given at length in the four volumes of the *Base Metrique.*

The English survey, which had been interrupted by the death of General Roy in 1790, was resumed in 1793 under the direction of Colonel Mudge. The original triangles between Greenwich and Dover were extended along the coast to Dunnose in the Isle of Wight, and thence through Devonshire and Wiltshire, and connected with a base of verification measured on Salisbury Plain. The length of this base was found, after the proper reductions, to be 36574·4 feet, differing scarcely one inch from the length deduced by calculation from the base on Hounslow Heath. So near a coincidence, though probably owing in some degree to a compensation of errors, affords a convincing proof of the extreme accuracy with which every part of the operation had been conducted. In 1802 the triangulation was carried into Yorkshire, and a meridian arc measured from Dunnose to Clifton. The latitudes at the terminal points were determined with Ramsden's zenith sector. The arc was afterwards extended to Burleigh Moor, and has since been carried to the Shetlands. It may be remarked that both the French and English arcs present this singular anomaly, that when portions of them, at particular places, are considered separately, the length of the degree appears to increase on going southward.

The survey has been continued, with occasional interruptions, up to the present time, under the able direction of Lieutenant-Colonel Colby;[1] and the triangulation has been carried to the remotest parts of Scotland, and over a considerable part of Ireland. In the course of the operations, several important improvements, both in respect of the instruments employed, and in the method of conducting geodetic measurements in general, have been introduced into practice. A base of upwards of seven miles has been measured near Londonderry; and it now only remains to determine the latitudes of some stations, to give us the elements of a new and greatly prolonged arc.

In the years 1801, 1802, and 1803, Maupertuis' Swedish arc was re-measured by Svanberg, and extended nearly 40′ in amplitude. The methods were the same as had been employed by Delambre. The extremities of the new arc were at Mallörn and Pahtawara. The distance was found to be 92,778 toises, and the difference of the latitudes 1° 37′ 20″·3; whence 1° = 57,196 toises. This agrees much better than the result of Maupertuis (57,422 toises) with other measures; but the difference, which implies an error of 12″ in the latitude of Kittis as determined by the French academicians, has not been satisfactorily accounted for; so that there is still some doubt about the length of the degree in that latitude. (See Svanberg's *Exposition des Operations faites en Lapponie,* &c. Stockholm, 1805.)

Since the beginning of the present century, two arcs of

[1] Since this article was written, Col. Colby has been succeeded by Col. Hall, and still more lately by Major James. (1855.)

Figure of the Earth.

meridian have been surveyed in India. The first was in the neighbourhood of Madras, and comprehended only 1° 35′. The second, however, is the longest which has yet been measured. The first, and a large part of the second, was accomplished under the direction of Colonel Lambton; and the instruments and methods of observation and calculation were exactly the same as those that had been employed by Colonel Mudge in the English survey. The southern extremity of the second arc was at Punnæ, near Cape Comorin, latitude 8° 9′ 32″·51; and the northern at Daumergidda, latitude 18° 3′ 16″·07. The amplitude is consequently 9° 53′ 43″·56, and the distance between the extremities was found to be 598,629·98 fathoms (about 680 miles), giving 60,495 fathoms, or 362,970 feet, for the length of the degree. Several bases were measured, and the whole of the operations appear to have been conducted with great skill and accuracy. This arc has since been extended by Captain Everest to Kaliana, latitude 29° 30′ 48″·8; so that the whole length now includes more than twenty-one degrees. The details of Colonel Lambton's operations are given in the different volumes of the *Asiatic Researches* (see vols. viii., x., xii.), and those of Captain Everest, in his "*Account of the Measurement of an Arc of the Meridian between the Parallels of* 18° 3′ *and* 24° 7′," printed at the expense of the East India Company.[1]

Various geodetic operations on a less extensive scale have been recently executed, which are better adapted, perhaps, to give information respecting the local curvature than the general form of the earth. Beccaria's arc has been remeasured by Plana and Carlini: the results clearly demonstrate the existence of some errors in the original measurement, but they are not yet altogether satisfactory, and the country is very unfavourable. The distance between Göttingen and Altona has been measured by Gauss; and the amplitude of the corresponding celestial arc is known with the utmost precision, from observations of the latitude made at the respective observatories of the two places. The amplitude, however, is only about two degrees, and there is some doubt about the exact length of the iron bars with which the base was measured. A more extensive arc has been measured in Russia by Struve. It extends at present to three and a half degrees, and it is understood that it is in contemplation to prolong it still farther.[2] Many new methods have been employed in this measurement; and it acquires additional value from its high latitude, and the acknowledged skill and accuracy of the observer.

The above are the principal arcs of meridian, but some arcs of parallel have also been measured. Theoretically speaking, the figure of the earth may be determined from the measurement of arcs of parallel, as readily as from meridional arcs; and the geodetical operations in the one case differ in no respect from those in the other. But the great, and, we fear, insurmountable difficulty, is to determine with sufficient precision the difference of astronomical longitudes. In a subsequent part of this article we shall have again occasion to mention Cassini's measurement of an arc of parallel across the mouth of the Rhone; of the English arc between Beachy Head and Dunnose; and that recently made from Marennes to Padua.

The problem of determining the earth's figure from the laws of hydrostatic equilibrium has not yet received the complete solution which the present advanced state of analytical science might lead us to expect. We have already mentioned the results found by Newton and Huygens. Maclaurin first demonstrated that the ellipsoid of revolution is a figure which satisfies the conditions of equilibrium in the case of a revolving homogeneous body, whose particles attract one another according to the law of the inverse square of the distance; and he moreover determined the amount of the attraction in a particle situated anywhere on the surface of such a body. This was an important step towards the solution of the problem. A few years afterwards, Clairaut published his *Théorie de la Figure de la Terre*, which, among other results, demonstrated with uncommon elegance, contained a very remarkable theorem which establishes a relation between the oblateness of the earth and the variations of gravity at different points of its surface, and consequently gives the means of determining the earth's figure by means of observations of the length of the seconds pendulum at different latitudes. Maclaurin's discovery gave the intensity of the gravitating force on the surface of the spheroid, or in its interior; but it was necessary to assign the force with which an exterior point is attracted. This was partly accomplished by D'Alembert, who proved that the attraction of any ellipsoid whatever upon a point situated in the prolongation of one of its axes, is to the attraction of a similar spheroid having the same centre, and passing through the attracted point, as the mass of the first spheroid is to the mass of the second. Legendre found an approximate expression by means of series, for the attraction on a point placed anywhere without a spheroid of revolution; and Laplace extended the solution to ellipsoids in general. But the complete solution was reserved for Mr Ivory, who obtained in finite terms a very simple expression for the attractive force of an ellipsoid on an exterior point, and thereby completed the theory of Maclaurin. It may be stated in a general way, that notwithstanding all the researches that have been made respecting this very intricate subject, the only positive results which theory has yet supplied are the three following:—1*st*, Maclaurin's demonstration that a homogeneous mass revolving about an axis will be in equilibrio with the figure of an ellipsoid of revolution; 2*d*, Clairaut's theorem for determining the ellipticity by means of pendulum observations; and, 3*d*, the expression for the attraction of ellipsoids on exterior particles, found by Mr Ivory. A complete theory would determine whether there are or are not other figures besides the ellipsoid, under which the equilibrium could subsist; but this has not yet been accomplished. Indeed it has not even been proved that the sphere is the only figure which could be assumed by a body at perfect rest, and whose molecules are subjected to no other forces than their mutual attractions.

Our limits do not permit us to enter into details respecting the numerous experiments that have been made of late years to determine the figure of the earth by measuring the variations of gravity at different places by means of the pendulum. The most valuable series of observations of this kind we yet possess are those of Captain Foster, reduced under the direction of Mr Baily, and published in the *Memoirs of the Royal Astronomical Society*, vol. vii. But a discovery recently made by Bessel proves that less accuracy has been obtained by this method than was supposed. It has been found, that a pendulum, when vibrating, drags along with it a portion of air, the precise effect of which can be ascertained in no other way than by actual experiment in vacuo with each individual pendulum. The probable correction which it would be necessary to apply to the results that have already been found, cannot be satisfactorily determined.

The mean of the pendulum experiments gives rather a higher value of the ellipticity than the results of geodetic measures; but there are many elements, particularly the irregular constitution of the exterior crust of the earth, and the density of the strata surrounding the station, which can scarcely be determined, and which yet affect materially the results of the experiments. This subject will be resumed under the article PENDULUM.

[1] See some account of this great work in Dissertation VI., chap. iii., sect. 4. (1855.)

[2] See as above.

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Besides the methods which have now been alluded to, physical astronomy furnishes other means of arriving at a knowledge of the figure of the earth. The precession of the equinoxes, and nutation of the earth's axis, are phenomena depending on the compression of the earth; and as their amount is now ascertained, from astronomical observations, with the utmost accuracy, we can reciprocally deduce from them a knowledge of the compression. They do not, however, give us an absolute value of the amount of compression, but they make known the limits within which it must necessarily be confined. These limits are $\frac{1}{279}$ and $\frac{1}{578}$. But a more delicate measure of the same element is furnished by some irregularities in the moon's motion to which it gives rise; and as the lunar theory has now attained a very high state of perfection, and as the small irregularities which cause so much perplexity in geodetical measures here entirely disappear, this is perhaps the most satisfactory method of all of determining the ellipticity of the earth. The equations into which the irregularity in question enters were discovered by Laplace; and the ellipticity necessary to produce the observed effect was found, on calculation, to be $\frac{1}{304}$; confirming in a most remarkable manner the deductions from the measurement of arcs and the observations of the pendulum.

SECTION II.

OF THE MEASUREMENT OF TERRESTRIAL ARCS.

The determination of the figure of the earth, being founded on the comparison of lines actually measured on its surface with the corresponding arcs of the celestial sphere, requires a combination of geodetical and astronomical operations, which it will be our object in the present section to explain. Theoretically considered, the geodetical line to be measured may lie in any direction, because it can always be reduced to the meridian or to any other given direction; but, for practical reasons, which will be pointed out hereafter, it ought to be taken, as nearly as the nature of the country in which the measurement is made will permit, either in the direction of the meridian, or of a parallel of latitude. Differences of latitude, however, can be determined with greater precision than differences of longitude; the meridional arcs are consequently the best adapted to the purpose. Satisfactory results can only be obtained from the measurement of lines of very considerable length, for example, of several degrees; and this circumstance renders the geodetical operations both laborious and complicated. In no place of the world, probably, and certainly in no populous country, could it be possible to find a territory so free from obstructions as to admit of the direct measurement of a line of two or three hundred miles in the same direction. Hence, when an operation of this nature is to be undertaken, the country in which the direction of the line to be measured lies is divided into triangles; the angles of each triangle are accurately observed with a theodolite, or some other equivalent instrument; and the side of one of them being actually measured, all the other sides are computed from it by the rules of trigonometry. In this manner the length of the whole line is ascertained, and on comparing it with the celestial arc, the data are obtained for deducing the dimensions and form of the earth.

It appears, then, that in order to determine the figure of the earth by the measurement of degrees, four distinct sets of operations are necessary: 1*st*, The measurement of one side of a triangle, or of *the base* as it is called; 2*d*, the observation of the angles of each triangle, together with the height of the station, in order that the triangles may be reduced, if necessary, to the horizontal plane, and to the level of the sea; 3*d*, the observation of the *azimuths* of the sides of the triangles, or the angles they make with the meridional line; 4*th*, the latitudes of the extreme points of the line. It is immaterial in what order these operations are undertaken. We shall begin with the measurement of the base.

The length of the base must be regulated in some degree by the nature of the locality; but being the fundamental element from which the sides of all the triangles are deduced, it should not be less than five or six miles. A piece of ground must therefore be selected, as nearly level as possible, and admitting a line of that length to be described on it. The direction of the base is first marked out by pickets; and, in order to place these in the same straight line, or rather in the same vertical plane, a telescope, mounted in the manner of a transit instrument, is set up at one extremity, by means of which the observer is enabled to direct an assistant, by signals, to the exact position in which the picket is to be placed, and also to bring their tops exactly into the same level. As a farther guide, a rope may then be stretched between the pickets; and, for greater security in the subsequent operations, the whole extent may be approximately measured by rods or chains, in the usual manner. The extremities of the base ought to be permanently marked by points. The centres of metal tubes, cannon for example, let into the ground to a considerable depth, answer this purpose very conveniently.

These preliminary operations being accomplished, the next step is to proceed to the more delicate operation of measuring the exact distance between the terminal points, or extremities of the base.

Various methods have been practised for this purpose. In the measurement of the first base of the trigonometrical survey on Hounslow Heath by General Roy, deal rods were at first employed, as had been done in almost all previous measures; but though every precaution was used in selecting the best seasoned timber, and every means employed to secure the rods from flexure, it was discovered, in the course of the operations, that they were liable, from variations in the state of the atmosphere as to moisture or dryness, to sudden and irregular changes of such magnitude as to destroy all confidence in the results. They were therefore laid aside; and glass rods, consisting of straight tubes twenty feet in length, and about an inch in diameter, and enclosed in wooden cases, were substituted. The only alteration to which these were subject arose from the expansion and contraction from variations of temperature; and as such alterations follow constant and ascertainable laws, their effects could be easily computed, and a correction made for them. But the apparatus ultimately adopted, both in the measurement of this base, and the other bases subsequently measured for the purpose of verifying the operations in the English survey, consisted of two steel chains, made with great care by Ramsden, of a hundred feet in length, and composed each of forty links, joined in the manner of a watch chain. The chains were supported by deal coffers, and after being placed in a straight line, were stretched with a weight of fifty-six pounds. Their temperature and inclination to the horizon were carefully noted at the same time, and the proper corrections subsequently made.

This method has been objected to, on account of the uncertainty of giving the chain always the same degree of tension, and of the rubbing and wear of the joints; but the best proof of the accuracy of the results obtained by it consists in the fact, that the two measurements of the base on Hounslow Heath, first by glass rods, and secondly

by the steel chains, differed from each other, after all the reductions were made, by less than three inches, although the whole length exceeded five miles. For an account of the comparison of the chains with one another, and with the standard brass yard made by Ramsden, we must refer to the *Philosophical Transactions*, vol. i.

The use of chains has been confined to the English and Indian surveys. For the determination of the meridian of Dunkirk, Borda employed rules of platina, exactly two toises in length, and furnished with a very ingenious contrivance for ascertaining the expansion. Along one side of the rule there was a slip of brass, firmly fixed at one extremity, but at liberty to move along the rule at the other end, according to the relative expansion of the two metals. The relative expansion being read off by means of a micrometer, gave a ready means of computing, from tables previously constructed, the absolute expansion of the platina rule. Four rules were made use of, three of which were always placed on the ground at once; and in order to prevent any derangement, they were not brought into absolute contact. A small interval of a few millimetres was left between them, which was measured by means of a slider attached to the preceding end of each rule, and which was pushed out till it came into contact with the following end of the preceding rule. See Delambre, *Astronomie*, tome iii. p. 538, or *Base du Systême Metrique*.

Various other contrivances have been used for the measurement of the base line. MM. Plana and Carlini, in the re-measurement of Beccaria's arc, employed measuring rods of wood, twelve metres in length, of the form of hollow parallelepipeds. For the Hanoverian base measure, between Altona and Gottingen, Gauss employed three rods of hammered iron each twelve French feet in length. But the most ingenious apparatus which has yet been invented for this purpose, is that which was made by our celebrated artist Troughton for the Irish base. As this instrument is probably destined to supersede all others previously used, we shall briefly describe the principle on which it is constructed.

Let AB and DE (Plate CCLVII. fig. 1) represent two bars of different metals, firmly united to a transverse bar at the middle C, but entirely free to move independently of each other at the extremities, according to their different expansions. AP and BQ are two tongues of steel attached to the extremities of the two rods AD and BE, by double conical joints, around which they are capable of making a small angle with the lines perpendicular to AB or DE. At a certain given temperature the bars are exactly of the same length, when, consequently, AP and BQ are parallel to each other, and perpendicular to the bars. Let us now conceive the bars to receive an increase of temperature, and that the dilatation of AB is greater than that of DE. In consequence of the increased temperature, both bars will be lengthened, but their lengths will no longer be equal; consequently the two tongues AP and BQ will no longer be parallel; for, suppose AB to become *ab*, and DE to become *de*, then AB being by hypothesis a more expansive metal than DE, *ab* will be longer than *de*, and the steel tongues will take the positions *ax* and *by*, inclined to each other. But if the point P is taken at such a distance from the bars that PA is to PD in the ratio of the dilatation of AB to DE, then in the new position *ax*, the point P will not sensibly deviate from the perpendicular AP, at least for moderate variations of temperature. In the same manner, the point Q will not sensibly deviate from its first position in the perpendicular BQ, so that the distance between P and Q remains sensibly the same. It is easy, however, to see that the dilatation of the bars must be confined within narrow limits; for, as the length of the tongue is invariable, P will not be found exactly in the line AP after the expansion has taken place; it will be on the same side of AP on which are the points a and d, and its distance from AP will be accurately measured by the quantity AP $\times$ (tan. APa — sin. APa); and as the same thing takes place with regard to Q, the distance between P and Q will be increased by twice this quantity. But as the angle APa must in all cases be extremely small, the difference between its tangent and its sine is altogether inappreciable. It is unnecessary to remark, that the same consequences (*mutatis mutandis*) take place when the temperature falls below the assumed standard.

In the instruments made use of in the measurement of the Irish base, the bar AB was of brass, and DE of iron. The length of each was ten feet, and the distance between them two inches. The length of the tongue is hence easily found from the relative dilatation of the two metals. Suppose the expansion of brass to be to that of iron in the ratio of 83 to 53 for an increase of 1° of temperature, and let PD $= x$ inches, we shall have $x : x + 2 = 53 : 83$; whence $x = \frac{53}{15} = 3\frac{1}{2}$ inches very nearly. But the precise position of the points P and Q must be determined by actual experiment: for the expansion or contraction of no two bars, even of the same metal, are ever found to be exactly the same.

In practice, five or six sets of bars, constructed in the manner now described, and placed in strong deal boxes supported on trestles, are laid along the line to be measured, and accurately levelled. They are placed at a small distance from each other, and the distance between the dots on the adjacent steel tongues of two succeeding bars is accurately measured by an ingenious micrometrical apparatus constructed so as to form a compensating instrument of exactly the same nature as the measuring bars.

The conception of this elegant apparatus belongs to Lieutenant-Colonel Colby; and the practical results it gives correspond with its theoretical excellence. It is computed that the greatest possible error of the base measured on the eastern shore of Lough Foyle, in the county of Londonderry, cannot exceed two inches, though the length is very nearly eight miles.[1]

The reduction to the level of the sea is made as follows: Let $r =$ radius of earth, $x =$ height above the level of the sea, $a =$ measured length of the base, and $a' =$ its reduced length; then

$$a' = a\left(\frac{r}{r+x}\right) = a\left(\frac{1}{1+\frac{x}{r}}\right) = a\left\{1 - \frac{x}{r} + \left(\frac{x}{r}\right)^2 -, \&c.\right\}$$

a series of which all the terms after the second may be neglected, by reason of their smallness.

It is easy to see, that as the base is not, correctly speaking, a straight line, but an arc of a circle, or rather ellipse, the sum of the lengths of all the rods or chains horizontally applied to it is not precisely the length of the arc, but of the circumscribing polygon. In order to determine how far this circumstance can affect the result, let us suppose the length of the measuring rod to be ten feet; when laid on the ground, exactly in the horizontal plane, it forms two tangents to the surface, of five feet each, and therefore each half length of the rod ought to be diminished by the difference between the tangent whose length is five feet, and the arc to which it belongs. Let A be the arc, then (ALGEBRA, Sect. XXV. H. 2)

[1] The three last bases measured in India, on which the northern half of the great meridional arc depends, were measured with an apparatus exactly similar. On the Cape arc, Colonel Colby's own bars were employed, having been sent for that purpose from Ireland, and the several parts of the base being compared with each other by triangulation, indicated a probable error of only 0·25 of an inch. (1855.)

$$\frac{A}{r} = \frac{\tan. A}{r} - \frac{1}{3}\frac{\tan. A^3}{r^3} + \&c.$$

whence $\tan. A - A = \frac{1}{3}\frac{\tan. A^3}{r^2} = \frac{125}{3r^2}$.

This must be multiplied by the number of times that the half rod, or five feet, is contained in the whole base. Supposing the base to be five miles, or 5280 times the length of the half rod, and the radius of the earth to be 4000 miles, or 4000×5280 feet, we should have $\tan. A - A = \frac{125}{3 \times 4000^2 \times 5280}$ feet; a quantity which is altogether insensible.

We come now to the triangulation. The first thing to be done is to select proper stations for the vertices of the triangles. The selection will necessarily depend on the nature of the country through which the survey is made; but there are certain principles which ought to be observed, as nearly as the circumstances will permit. The stations should be chosen so that each angle of the principal triangles should approach as nearly as possible to 60°, because a small error in the estimation of a very acute or obtuse angle will greatly affect the length of the opposite side computed from it. Excepting in unavoidable cases, no angle ought to be less than 30°. The sides cannot be too long, while the signal at one extremity is visible from the other. The signals may be towers, spires, or other conspicuous objects conveniently situated; but such signals can seldom be well bisected by the wire of the telescope. Flag-staffs are better when the distances are not too great. Delambre preferred signals erected on purpose. They were generally constructed of wood, and of the form of a truncated pyramid. One considerable advantage arises from the use of signals constructed in this manner, namely, that the instrument can be placed exactly at the centre of the station. Frequently Bengal lights, reverberating lamps, and white lights, are employed; but these of course can only be seen during the night. The best signal of this sort was invented by Lieutenant Drummond. It is formed by directing a stream of hydrogen gas on a small piece of ignited quicklime; an intense light is produced, which may be seen at very great distances. Care should be taken to place the signals, if they are to be observed by day, in such positions that they may be projected on the sky; if projected on forests or mountains, they will seldom be distinctly visible. Svanberg constructed his signals with openings, to permit the light of the sky to be seen through them.[1]

The triangles being marked out, and the signals prepared, the next object is to measure the angles. When the theodolite is used for this purpose, no correction is required on account of the different altitudes of the signals, the reduction being effected by the instrument itself; but when a sextant or repeating circle is employed, the observed angles must be reduced to the plane of the horizon.

Let P, Q, and R (fig. 2) be the three stations, PQR the observed angle oblique to the horizon; produce PQ and PR till they meet Q′ R′, a line parallel to the plane of the horizon; through Q′ R′ let a plane be conceived to pass parallel to the horizontal plane, meeting PZ, the vertical passing through P, in P′; then Q′ P′ R′ is the horizontal projection of QPR, and the angles ZPQ, ZPR are the complements of the inclinations of the line PQ and PR to the horizon.

With P as a centre, and a radius = 1, let a sphere be described, intersecting PZ, PQ, and PR in the points A, B, and C respectively; the angle BAC is evidently equal to the horizontal angle Q′P′R′. Now, in the spherical triangle ABC, we have given by observation the side AB = the zenith distance of Q, AC = the zenith distance of R, and BC the oblique angle at the centre of the station, from which we are to find the angle BAC = Q′P′R′.

Let BC = a, AC = b, AB = c, and BAC = A. By a well-known formula of spherical trigonometry,

$$\cos. A = \frac{\cos. a - \cos. b \cos. c}{\sin. b \sin. c}; \text{ but } \cos. A = 1 - 2\sin.^2 \tfrac{1}{2} A,$$

$$\text{therefore } 2\sin.^2 \tfrac{1}{2} A = 1 - \frac{\cos. a - \cos. b \cos. c}{\sin. b \sin c},$$

$$\text{and } 2\sin.^2 \tfrac{1}{2} A = \frac{\cos. (b-c) - \cos. a}{\sin. b \sin. c}.$$

Now, if p and q denote two arcs, we have (ALGEBRA, XXV. D),

$$\cos. p - \cos. q = -2\sin. \tfrac{1}{2}(p+q)\sin. \tfrac{1}{2}(p-q),$$

therefore

$$\cos. (b-c) - \cos. a = -2\sin. \tfrac{1}{2}(a+b-c)\sin. \tfrac{1}{2}(b-c-a) = 2\sin. \tfrac{1}{2}(a+b-c)\sin. \tfrac{1}{2}(a-b+c),$$

and the equation becomes

$$\sin.^2 \tfrac{1}{2} A = \sin. \frac{\tfrac{1}{2}(a+b-c)\sin. \tfrac{1}{2}(a-b+c)}{\sin. b \sin. c}$$

Let $\frac{1}{2}(a+b+c) = s$; then $\frac{1}{2}(a+b-c) = s-c$, and $\frac{1}{2}(a-b+c) = s-b$; consequently

$$\sin. \tfrac{1}{2} A = \left(\frac{\sin. (s-c)\sin. (s-b)}{\sin. b \sin. c}\right)^{\frac{1}{2}}$$

From this formula the value of A is easily computed, when the inclinations of the lines PQ and PR to the horizon are not very small. In practice, however, it frequently happens that these inclinations are very small, or that the angles b and c differ very little from right angles. When this is the case, the logarithmic calculation of the formula becomes troublesome, particularly if it is required to determine A with great exactness; and it is better to adopt a different method of proceeding.

Instead of seeking to find the projected angle Q′P′R′, we may find its difference from the observed angle QPR, which difference will seldom amount to more than a few seconds. Since the arcs b and c are supposed to differ little from 90°, if we make $b = 90° - \beta$, $c = 90° - \gamma$, the angles β and γ will be very small. Substituting these values of b and c in the formula

$$\cos. A = \frac{\cos. a - \cos. b \cos. c}{\sin. b \sin. c}$$

it becomes

$$\cos. A = \frac{\cos. a - \sin. \beta \sin. \gamma}{\cos. \beta \cos. \gamma};$$

but

$$\sin. \beta = \beta - \frac{\beta^3}{6} + \&c., \sin. \gamma = \gamma - \frac{\gamma^3}{6} + , \&c.$$

$$\cos. \beta = 1 - \frac{\beta^2}{2} + \&c., \cos. \gamma = 1 - \frac{\gamma^2}{2} + , \&c.$$

therefore, on substituting, and rejecting all terms above those of the second order, we have

$$\cos. A = \frac{\cos. a - \beta\gamma}{1 - \frac{1}{2}(\beta^2 + \gamma^2)} = \cos. a - \beta\gamma + \tfrac{1}{2}(\beta^2 + \gamma^2)\cos. a.$$

Let A = $a + x$. It is evident that when β and γ both vanish, x also vanishes, and we get A = a. Hence if β and γ be both very small, x is also very small, and consequently we may suppose its cosine = 1, and its sine = x. In this case $\cos. A \left\{= \cos. (a + x)\right\} = \cos. a \cos. x - \sin. a \sin. x$ becomes

$$\cos. A = \cos. a - x \sin. a.$$

Equating this with the former value of cos. a, we get

$$x \sin. a = \beta\gamma - \tfrac{1}{2}(\beta^2 + \gamma^2)\cos. a$$

whence

$$x = \frac{\beta\gamma - \frac{1}{2}(\beta^2 + \gamma^2)\cos. a}{\sin. a}.$$

[1] The best signal of all, and that which has been generally employed on the Irish, and later portions of the Indian surveys, is the Heliostat or Heliotrope, in which the sun's rays reflected from a plane mirror are passed through an aperture in a vane plumbed exactly over the centre of the station, the appearance produced at a distance is exactly that of a bright star. An aperture of 2 inches was found sufficient for a distance of 30 miles, and the signal has been employed at distances of 100 and upwards. (1855.)

Figure of the Earth.

In order to adapt this fraction to logarithmic computation, let both its numerator and denominator be multiplied by 2; then, because $\cos. a = \cos.^2 \frac{1}{2}a - \sin.^2 \frac{1}{2}a$, and $2\beta\gamma = 2\beta\gamma \cos.^2 \frac{1}{2}a + 2\beta\gamma \sin.^2 \frac{1}{2}a$, we find, on multiplying and reducing,

$$2\beta\gamma - (\beta^2 + \gamma^2) \cos. a = (\beta + \gamma)^2 \sin.^2 \tfrac{1}{2}a - (\beta - \gamma)^2 \cos.^2 \tfrac{1}{2}a;$$

but $\sin. a = 2 \sin. \frac{1}{2}a \cos. \frac{1}{2}a$; therefore, by substitution,

$$x = \left(\frac{\beta+\gamma}{2}\right)^2 \tan. \tfrac{1}{2}a - \left(\frac{\beta-\gamma}{2}\right)^2 \cot. \tfrac{1}{2}a.$$

Here the arcs x, β, γ are expressed in parts of the radius; but they are given by observation in minutes and seconds. Now an arc of 1″ may be considered as equal to its sine: hence the arc in seconds is to the arc in parts of the radius as 1″ to sin. 1″; consequently the arc in feet is equal to the arc in seconds × sin. 1″. Multiplying, therefore, by sin. 1″, we get

$$x = \left\{ \left(\frac{\beta+\gamma}{2}\right)^2 \tan. \tfrac{1}{2}a - \left(\frac{\beta-\gamma}{2}\right)^2 \cot. \tfrac{1}{2}a \right\} \sin. 1''$$

Another reduction is necessary. Unless the signals are constructed on purpose, it will rarely happen that the instrument can be placed exactly in the centre of the station.[1] In this case it must be placed at some other point near the centre of the station, and the observed angle reduced to the centre by calculation. Suppose, for example, it were required to determine the angle ACB (fig. 3), which the objects A and B subtend at C, and that the instrument cannot be placed exactly at C. Let P be the point, at a short distance from C, where the instrument is actually placed, and APB be the observed angle; then, since CP can be measured, and CA, CB are supposed to be known, approximately at least, the problem is, having given the angle APB, and the distances CA, CB, and CP, it is required to determine the angle ACB.

Let AC and BP intersect in E. Then, since AEB = ACB + CBP = APB + CAP, we have

$$ACB - APB = CAP - CBP.$$

But $\sin. CAP = \frac{CP}{CA} \sin. CPA$, and likewise $\sin. CBP = \frac{CP}{CB} \sin. CPB$; therefore, making $AC = m$, $BC = n$, $CP = d$, $ACB = C$, $APB = P$, $CPB = p$, then $CPA = P + p$, and by substitution,

$\sin. CAP = \frac{d}{m} \sin. (P+p)$, and $\sin. CBP = \frac{d}{n} \sin. p$, whence, dividing by sin. 1″ to reduce the expression to seconds,

$$CAP = \frac{d}{m} \frac{\sin. (P+p)}{\sin. 1''}, \text{ and } CBP = \frac{d}{n} \frac{\sin. p}{\sin. 1''};$$

therefore (since $CAP - CBP = ACB - APB = C - P$),

$$C - P = \frac{d \sin. (P+p)}{m \sin. 1''} - \frac{d \sin. p}{n \sin. 1''},$$

which gives C, or the angle ACB, expressed in seconds of a degree.

This expression is exact; but an approximation more convenient for calculation, and sufficient in almost every case that can occur in practice, was generally followed by Delambre. Let a circle be described about the triangle ABC, intersecting BP in D, and let CD, DA, and AB be joined. We have then ACB − APB = ADB − APB = DAP. Let the angle CDB (= CAB, which is known by observation) be denoted by A. In the triangle DPA,

$$\sin. DAP = \frac{DP}{AD} \sin. APB = \frac{DP}{AD} \sin. P,$$

and in the triangle DPC,

$$DP = PC \frac{\sin. PCD}{\sin. CDB} = PC \frac{\sin. (CDB - CPB)}{\sin. CDB},$$

$$\text{or } DP = d \frac{\sin. (A-p)}{\sin. A}; \text{ therefore}$$

$$\sin. DAP = \frac{d}{AD} \frac{\sin. (A-p)}{\sin. A} \sin. P.$$

But AD may be considered as equal to AC = m; whence $\sin. DAP = \frac{d \sin. (A-p) \sin. P}{m \sin. A}$, and consequently, when expressed in seconds,

$$DAP = C - P = \frac{d \sin. (A-p) \sin. P}{m \sin. A \sin. 1''}.$$

This expression vanishes when $A - p = 0$, or when the points P and D coincide, that is, when the instrument is placed on the circumference of the circle circumscribing the triangle ACB. And it may be so placed, unless obstacles intervene, by moving it along the line PB, till the angle CDB is observed to be equal to BAC.

When the three observed angles of each triangle have been reduced to the horizon, they represent the angles of a spherical triangle, the sides of which are intercepted by the verticals of the three stations, and the sum of the three angles of each triangle exceeds 180° by a quantity which is called the *spherical excess*. The sides ought therefore to be calculated by the rules of spherical trigonometry; but as the sides of the triangles are in all cases very small in comparison of the radius of the earth, the calculation made in this way (for which indeed the existing tables are not well adapted) becomes exceedingly tedious. Instead, therefore, of calculating directly the spherical triangle, it is more convenient to compute its deviation, which is always very small, from a plane triangle. The method employed by Delambre was the following.

In the first place, the spherical angle, or that which is formed by tangents at the surface, must be reduced to the corresponding plane angle formed by the chords. This is easily accomplished by the help of the theorem above given for reducing the observed angles to the horizon; for the angle formed by the chord and the tangent of an arc is equal to the angle at the centre subtended by half the arc; consequently when the lengths of the two sides of a spherical angle are known nearly, the angle of *depression* of the chords is also known; and therefore the preceding theorem for reducing angles to the horizon can be immediately applied. For example, suppose the sides of a spherical angle to be respectively p and q miles, and the circumference of the earth to be 25,000 miles, then

$$25{,}000 : p :: 360° : \frac{360°\, p}{25{,}000}, \text{ or } \frac{21{,}600''\, p}{25{,}000} = \frac{108\, p}{125} \text{ seconds}$$

of a degree, which is the angle subtended at the centre by the whole arc; and consequently one half of it, or $\frac{54''\, p}{125}$, is the depression of the chord. In the same manner, $\frac{54''\, q}{125}$ is the depression of the chord of q; and by substituting these in the formula

$$x = \left\{ \left(\frac{\beta+\gamma}{2}\right)^2 \tan. \tfrac{1}{2} a - \left(\frac{\beta-\gamma}{2}\right)^2 \cot. \tfrac{1}{2} a \right\} \sin. 1'',$$

we obtain the angles made by the chords, by means of which the triangle may be computed in the same manner as if it were a plane triangle.

To make this reduction, it is necessary to know, approximately at least, the diameter of the earth as well as the distances of the stations; but the result will be little affected by a moderate error in either of these data. In fact, it is only when the sides of the triangles are very large that the effects of the earth's curvature become at all sensible.

But a more elegant manner of estimating the effects of the earth's curvature, though not always of so easy application, was proposed by Legendre. This illustrious geometer discovered the following very remarkable property of spherical triangles; namely, that when the sides are very

[1] This should always be done if possible, and when light signals are used there can rarely be any necessity for a deviation of this kind. (1855.)

small in comparison of the radius of the sphere, if from each of the angles there be subtracted one-third part of the quantity by which the sum of the three angles exceeds two right angles, or 180°, the angles thus diminished may be regarded as the angles of a plane triangle, the sides of which are equal in length to those of the proposed spherical triangle. The excess of the sum of the three angles above two right angles is proved by trigonometry to be equal to $\frac{a}{r^2}$, a being the area of the triangle, and r the radius of the sphere; so that the theorem of Legendre may be enumerated as follows:—

"If the angles of a spherical triangle whose surface is small in comparison of the surface of the whole sphere, be denoted by A, B, and C, and the opposites by a, b, and c, the triangle may be calculated as a plane triangle, the sides of which are a, b, and c, and the opposite angles $A - \frac{1}{3}\epsilon$, $B - \frac{1}{3}\epsilon$, $C - \frac{1}{3}\epsilon$, ϵ being the excess of the sum of the three angles of the proposed spherical triangle above two right angles."

In applying the above theorem, it is necessary first to calculate ϵ or $\frac{a}{r^2}$, which can always be done *a priori* from the known parts of the spherical triangle considered as rectilinear. This being done, we have only to deduct $\frac{1}{3}\epsilon$ from each of the observed angles, and then compute the remaining parts, as in the case of a plane triangle.

By this method, the distances between the several signals may be computed; and as the angles at all the stations are given by observation, the inclinations of all the sides of the triangles to any one of them are also known, so that it is only necessary to determine very accurately the inclination of one side of a triangle to the meridian, in order to ascertain the inclinations of all the other sides, and thence to compute the meridian itself.

The determination of the azimuth of a signal is accomplished by means of astronomical observation, and may be performed in various ways, but all depending on the same principle. It is necessary, however, in any case to be provided with the means of determining the time with very great precision. The azimuth of the sun, or a star, at any given instant, can be determined with sufficient accuracy. Let the observer, therefore, take his station at one of the signals, and observe the angle formed between the other signal and the sun, or a star, when nearly in the horizon, and let him note the instant of time at which the observation was made. Knowing the error of his clock or chronometer, he knows also the true time, and can consequently calculate the azimuth of the observed celestial body. Taking the sum or difference, as the case may be, of this and the observed angle, he obtains the azimuth of the distant signal, or the angle which the straight line joining the two signals makes with the meridian. The refraction will scarcely affect the result; but a small error with respect to the time would lead to considerable errors. If the sun is observed, the error of the clock must be determined by observations of his meridional transits; but most frequently a circumpolar star, as Capella, is preferred. Sometimes the observation is made on the pole star itself; but in this case it is necessary to know the latitude of the station very accurately. Another method is frequently resorted to. Having set up a mark very nearly in the meridian, adjust a transit instrument upon it, and then, by means of the transits of stars at different polar distances, or other means known in practical astronomy, determine the deviation of the instrument from the meridian. This gives the direction of the mark with respect to the meridian, and consequently the angle to be added to or subtracted from the angle between the mark and the signal.[1] For greater security, the azimuths may be observed at several signals. They ought at least to be observed at each extremity of the chain of triangles.

The triangles being calculated and reduced to the horizon, we are now in a condition to compute the length of the arc between the parallels of the extreme stations. Let ABCDEFG, &c. (fig. 4), be a chain of triangles lying nearly in the direction of the meridian AZ, and traced on a spheroidal surface, supposed to be formed by the continuation of the ocean. Let L be the last station, and LX the perpendicular passing through L and meeting AZ in the point X; it is required to determine AX.

By means of the previous calculations, all the sides of the triangles are supposed to have been computed, as well as the azimuth of C, or the inclination of AC to the meridian. Let CD be produced to M. In the triangle ACM there are given the side AC, and the two angles CAM, ACM. To find the third angle AMC, first compute the spherical excess ϵ; from each of the angles CAM, ACM, subtract $\frac{1}{3}\epsilon$; take the sum of the two remainders from 180°, and there will be left the value of AMC. The angles being thus given, and also the side AC, the other two sides AM and CM are computed in the same manner as if the triangle were rectilinear.

In the quadrilateral MDFN there are given the two opposite angles at M and F (the first from the previous calculation, and the second by observation), together with the two sides MD and DF. Draw the diagonal MF; then in the triangle DMF there are given the two sides DM, DF, and the included angle D. From D deduct $\frac{1}{3}\epsilon$, the excess ϵ being computed by an approximate value of the area of the triangle, and compute, as in a plane triangle, the side MF and the two angles DMF, DFM. To each of these add $\frac{1}{3}\epsilon$, and the two sums being deducted from the angles DMN and DFN, there will remain the two angles FMN and MFN. Hence, since MF has been already computed, we can find MN, FN, and the angle MNF, in the usual manner.

Now, in the triangle NPH, NH is known (for FH and FN have been calculated), and the adjacent angles PNH, NHP are given by observation; therefore we can compute NP, PH, and the remaining angle NPH.

To find PX we may produce IL to Z, and resolve the two triangles PIZ and ZLX. In the first of these, the side PI, and the two adjacent angles PIZ, IPZ, are already known; whence we find IZ, PZ, and the angle IZP. We have then in the right-angled triangle LXZ, the side LZ, and the angle LZX to find ZX. From PZ subtract ZX, and there remains PX, the quantity sought.

In proceeding by the method now indicated, the spherical excess ϵ must be first computed for each of the triangles to be resolved; then each observed spherical angle must be diminished by $\frac{1}{3}\epsilon$, in order to allow the calculations to be made by the rules of plane trigonometry; and when the result has been found, we must again add to each angle the small quantity $\frac{1}{3}\epsilon$, in order to have the true spherical angle. (See Delambre, *Methodes Analytiques pour la Determination d'un Arc du Meridien.*)

It is necessary to remark, that the point X, determined by drawing a perpendicular from the last station to the meridian, is not situated exactly on the same parallel of lati-

[1] The most accurate method, being that followed in all the later operations of the Indian survey, is to select a star within a few degrees of the pole, and observe its angular deviation from a fixed mark at both elongations E. and W. of the meridian. The mean of these two angles will give the true azimuth of the mark free from any error in the place of the star; as the star moves slowly in azimuth when near its elongation, a small error in the time is also of no consequence. The star should be selected so as to arrive at its elongations not far from sunrise and sunset, and several observations may be made at each elongation. (1855.)

tude with L. Its latitude is a little greater than that of L; and unless the distance of the station from the meridian is very small, the difference will be sensible, and requires to be calculated. Conceive another point, L′ (fig. 5), on the same parallel of latitude with L, and at the same distance from the meridian on the opposite side. The point X is on the circumference of a great circle, perpendicular to the meridian PE, and passing through L and L′; but the small circle, or parallel of latitude of L and L′, intersects the meridian in a different point l. Now let PE (fig. 6) be the meridian, XC the intersection of its plane with that of the great circle passing through the points LL′, and ln the intersection of the plane of the meridian and the plane of the small circle or parallel of latitude passing through the same points LL′, so that El is the latitude of L, EX that of the point X, and lX the distance between the perpendicular and the small circle passing through L. Let ln and XC intersect in m, then lX being a small arc, may be regarded as a straight line; consequently $\mathrm{X}l = m\mathrm{X} \tan. \mathrm{X}ml$. But $\mathrm{X}ml = \mathrm{XCE}$ = latitude of L very nearly, consequently, taking λ to denote the latitude of L, we have $\mathrm{X}l = m\mathrm{X} \tan. \lambda$. Now mX is the versed sine of the arc whose chord is LX; therefore, making d=earth's diameter, $m\mathrm{X} = \frac{\mathrm{LX}^2}{d}$, and consequently $\mathrm{X}l = \frac{\mathrm{LX}^2}{d} \tan. \lambda$, which is the quantity to be subtracted from the calculated meridional arc.

Delambre employed a different method of computing the distance between the parallels of the terminal points of the measured arc. It requires, however, the dimensions of the earth to be previously known with tolerable accuracy. Let AB (fig. 7) be the arc measured on the surface of the spheroid PAB; then, having observed the latitude of the station A, and the azimuth of AB, that is the angle BAP, we have sufficient data, supposing the dimensions of the earth to be nearly known, to find not only the distance between the parallels of A and B, but also the latitude and longitude of B, and the azimuth of BA, as observed from B. Through A and B draw the normals AM and BN, meeting the axis in M and N; join BM, AN; and about M as a centre, with an arbitrary radius, describe the circular arcs bp, pa, ab, forming the spherical triangle pab. Now, if we compare the triangle PAB on the spheroid with pab on the sphere, we find pa=PA in degrees, each being the colatitude of A; pb=PB, each being the colatitude of B; the angle apb =APB being the difference of longitude of A and B, and also the angle pab=PAB, each measuring the inclination of the planes PMA, AMB. But the angle pba is in general not equal to PBA; for as the normals do not meet the axis in the same point, the planes AMB and ANB do not coincide; and pba is the measure of the inclination of PMB and AMB, whereas PBA is the measure of the inclination of PMB and ANB. Now, in the triangle pba there are given the angles at p and a, so that if the side ab can be determined in terms of AB, the other parts of the triangle may be computed, and thence the difference between pb and pa, or the distance between the parallels, which being found in terms of BA, will be expressed in feet.

We have therefore to find an expression for ab, or the angle AMB. Now, in the triangle ABM there are given AB (the measured arc), and AM the normal at A (the dimensions of the earth being nearly known). But $\mathrm{BM} = \mathrm{BN} \frac{\sin. \mathrm{MNB}}{\sin. \mathrm{NMB}}$; and if we make l = PNB the colatitude of B, and x = NBM, we shall have NMB = PNB $- x = 90° - l - x$; therefore sin. NMB = cos. $(l + x)$; we have also sin. MNB = sin. $(90° - l)$ = cos. l; wherefore $\mathrm{BM} = \mathrm{BN} \frac{\cos. l}{\cos. (l+x)} =$

$$\mathrm{BN} \frac{\cos. l}{\cos. l \cos. x - \sin. l \sin. x} = \mathrm{BN} \frac{1}{\cos. x - \tan. l \sin. x}$$

$$= \mathrm{BN}\ (1 + \tan. l \sin. x + 2 \sin.^2 \frac{x}{2} +, \&c.$$

Now x is a very small angle; its sine is in fact expressed in terms of the square of the excentricity, so that terms multiplied by it may be neglected without any sensible error. We may therefore assume BM=BN. In the triangle ABM we have then given the three sides, whence the angles may be computed, and consequently ab=AMB becomes known.

Having found ab, we have given in the triangle abp the two sides pa, ab, and the observed angle pab, from which to compute the remaining parts of the triangle, viz. pb the latitude of B, apb its longitude, and pba the azimuth of A, as seen from B. Make $pa' = pa$, and Pb' to PB, then $ba' = pb - pa$ is the distance between the parallels, the radius being unit; therefore, since 1 : MA :: $a'b$: Ab', we have $\mathrm{A}b' = \mathrm{AM} \times a'b$, that is, the distance between the parallels of the extreme stations on the spheroid.

When the distance between the parallels of the extreme points of the arc has been ascertained, it only remains to determine the difference of their latitudes, or the length of the corresponding celestial arc. This is the most difficult part of the whole operation. The error of a single second in the difference of the latitudes corresponds to about a hundred feet on the terrestrial meridian; and when it is considered that the latitudes of the best determined spots on the earth, even of the Observatories of Greenwich and Paris are still uncertain to the amount of at least half a second, it will be easily apprehended that the errors of the latitudes are more to be feared than any which can affect the measurement of the base, or the angles, or the direction of the meridian. In the British survey, that of India, and some on the Continent, the latitudes were observed with the zenith sector, an instrument peculiarly adapted to this purpose. Ramsden's zenith sector, made expressly for the determination of the arc of meridian between Dunnose and Clifton, carried a telescope of eight feet in length. With this superb instrument, for a description of which we must refer to the second volume of the *Trigonometrical Survey*, the zenith distances of several of the northern stars were observed at both extremities of the arc; and the difference of two zenith distances of the same star is evidently the same as the difference of the latitudes of the two stations. It may be remarked, that the result of this observation is independent of the declination of the star; and if the observation is made at the second station within a short time after it was made at the first, the result is also nearly independent of the nutation.[1]

For the determination of the French arc of meridian, the latitudes were observed with the repeating circle. This instrument, on account of its portability, is of the greatest use in geodetic operations; but it may be questioned whether it can be safely relied on for the determination of so very important an element as the latitude. Besides the want of power in the telescope, it is found to be affected in some unaccountable way by a constant error, which, however carefully its amount may have been determined, leaves a degree of uncertainty with regard to the results. Mechain mistook the latitude of Barcelona by about 3″. It is to be regretted that the latitudes of Dunkirk and Formentera, the extremities of the French arc,

[1] The latitudes of the later portions of the Indian meridional arc were measured by simultaneous observations at each extremity of the same stars, with 3-feet altitude and azimuth circles; a method every way preferable to that with the sector. (1855.)

have not been determined with the zenith sector. All the other operations connected with the measurement of that extensive arc have been executed in a style of such decided superiority, that a more satisfactory, if not more accurate, determination of the latitudes is alone wanting to render it the most valuable application of science that has ever been made with a view to ascertain the magnitude and exact figure of our globe.

The measurement of an arc of parallel usually forms part of the operations connected with the survey of a large extent of country. It will frequently happen that the sides of some of the great triangles lie in a direction nearly perpendicular to the meridian, in which case the arc of the terrestrial parallel may be easily computed from an approximate knowledge of the earth's dimensions; and if the difference of longitude of the two stations, or the angle which their respective meridians make with each other, has been accurately determined, the comparison of the corresponding celestial and terrestrial arcs will give the length of the degree on the parallel. By comparing this result with the length of a degree measured on a different parallel, or on the meridian, we can easily deduce the ellipticity.

Perhaps the simplest way of conveying an accurate idea of the nature of the operations necessary to be undertaken in the measurement of an arc of parallel, will be to describe the method that was actually followed in the British trigonometrical survey, in determining the length of an arc of parallel from the measured distance between Beachy Head and Dunnose.

Let BW (fig. 8) be an arc of the great circle perpendicular to the meridian of Beachy Head at B, meeting that of Dunnose in W; and let DR be an arc of the great circle perpendicular to the meridian of Dunnose at D, meeting that of Beachy Head in R; and let BL and DE be the parallels of latitude passing through B and D. It is supposed that the latitudes of the two places have been determined, together with the angles PBD and PDB, which they reciprocally make with each other and the pole; and also that the distance between them on the arc of the great circle has been measured: the question is then to find the difference of their longitudes, or the angle BPD, and the distance in feet between the meridians on the arcs of the small circles BL and DE passing through the places.

In the small spheroidal triangle WBD there were given by observation the two angles WBD and WDB, which being reduced to the angles made by the chords, gave the two angles of the corresponding plane triangle. The side BD was found by triangulation = 339,397·6 feet; whence the chord of the perpendicular arc BW was found = 336,115·6 feet. In like manner the chord of DR was found = 336,980 feet.

The terrestrial distances being thus found, it was next necessary to find the difference of longitude, or the angle P, and the lengths of the arcs of parallel BL and DE in degrees. For this purpose there are given PB the colatitude of B, PD the colatitude of D, the angle PBD, which is the azimuth of D as seen from B, and PDB the azimuth of B as seen from D.

The rigorous solution of this problem on the spheroid is attended with considerable difficulty. An approximation is however easily obtained from a property of spheroidal triangles (for the demonstration of which we must refer to the *Phil. Trans.* vol. lxxx.), namely, that the sum of the horizontal angles on a spheroid (or indeed on any surface differing little from that of a sphere) is *nearly* the same as the sum of those which would be observed on a sphere, the latitudes and difference of longitudes being the same on both figures. Assuming therefore the sum of the two angles PDB and PBD to be the same as the sum of two spherical angles, we have, from Napier's analogies (see TRIGONOMETRY),

$$\cos.\tfrac{1}{2}(PD+PB):\cos.\tfrac{1}{2}(PD-PB) = \cot.\tfrac{1}{2}P:\tan.\tfrac{1}{2}(PDB+PBD),$$

whence

$$\tan.\tfrac{1}{2}P=\frac{\cos.\frac{1}{2}(PD-PB)}{\cos.\frac{1}{2}(PD+PB)}\times\cot.\tfrac{1}{2}(PDB+PBD);$$

that is to say, the tangent of half the difference of longitudes is equal to the cotangent of half the sum of the azimuthal angles multiplied into the ratio of the cosine of half the difference of the colatitudes to the cosine of half their sum. In the case under consideration the angle P was found = 1° 26′ 47″·93.

We have now given, in the right-angled triangle PBW, which may be considered as spherical, the side PB and the angle P, whence BW was found = 54′ 56″·21. And from the triangle PDR, in which the side PD and the angle P are given, DR was found = 55′ 4″·74.

The chords of the two perpendicular arcs BW and DR, whose radius is the radius of the earth, are found, from an approximate knowledge of the earth's diameter, to be three feet and a half shorter than the arcs themselves, whence the arc BW = 336,119·1 feet, and DR = 336,983·5 feet. Hence the length of the degree of the great circle perpendicular to the meridian, at the middle point between W and B, is found by proportion = 367,096·8 feet, and in the middle point between R and D = 367,090·8 feet. Therefore the mean, or 367,093·8, is the length of a degree of the great circle perpendicular to the meridian in latitude 50° 41′, which is nearly that of the middle point between Beachy Head and Dunnose.

Now, by reason of the short distance between the two stations, and their small difference in latitude, the two radii of curvature at B and D may be regarded as intersecting each other on the axis at M (fig. 9). Therefore DM is the radius of the great circle perpendicular to the meridian, and DE is the radius of the parallel at D. Therefore 1° of the great circle : 1° of the parallel as DM : DE; and DM : DE = 1 : cos. latitude of D; whence 1 : cos. 50° 44′ 24″ = 367,094 : 232,314 feet for the degree of parallel at Beachy Head, and 1 : cos. 50° 37′ 7″ = 367,094 : 232,914 feet for the degree of parallel at Dunnose. (*Trig. Survey,* vol. i. p. 113.)

The length of the degree of the great circle perpendicular to the meridian, deduced in the manner now explained, is about 1250 feet greater than on the spheroid which corresponds with the measurements of the meridional arcs. This discrepancy gave rise to a suspicion of errors in the observation of the azimuthal angles; and, in fact, the difference of longitude, in order to agree with other determinations, ought to be about 18″ greater than that which was determined in the survey. With this correction the length of the degree of the perpendicular circle is found = 365,838 feet. Assuming the dimensions of the earth deduced from the survey, the length of the degree perpendicular to the meridian at the mean latitude is 365,844 feet. Hence 1° parallel = 231,801 feet.

In the *Philosophical Transactions* for 1824 an account is given of some experiments performed by Dr Tiarks for determining the difference of longitude of Dover and Falmouth. Twenty-four chronometers were transported by sea, three several times, from the one place to the other, by which means the difference of the apparent times was determined. The difference of longitude was thus found to be 6° 22′ 6″; and the length of the parallel, as found from the survey, being 1,474,672 feet, we have the length of a degree of parallel at latitude 50° 44′ 24″ = 231,563 feet.

The most extensive arc of parallel which has yet been

measured is that between Marennes (near Bordeaux) and Padua. The details of the operations, which were performed in 1822 and 1823, are given in the *Connaissance de Tems* for 1829. The terrestrial arc was determined by triangulation in the usual manner, and the astronomical amplitude by fire signals observed from station to station at five intermediate stations. There are consequently six independent arcs; and the final result is affected with the accumulated errors at all the stations. The terrestrial distance was found to be 1,010,996 mètres, or 3,316,976 English feet; and the difference of time determined by chronometers 51 min. 56·24 sec., corresponding to 12° 59′ 3″·75 of longitude. The mean length of the degree, found from the partial arc between Marennes and Geneva, is 255,546 feet, and from the whole arc between Marennes and Padua 255,470 feet, both of which results are greater than the degree on the regular spheroid, which is found to represent most nearly the meridional arcs under the same parallel of latitude, namely, 45° 43′ 12″. A better example has been afforded by the measurement in 1845 of the arc of parallel between Greenwich and Valentia (Ireland) by the Astronomer Royal; while the instantaneous transmission of time signals by the electric telegraph, which has arisen even since that late date, is (1855) being employed by many astronomers in Europe and America for supplying still better materials for new arcs of *parallel*, and making them indeed of as much scientific importance as arcs of the *meridian*.

SECTION III.

DETERMINATION OF THE FIGURE OF THE EARTH FROM GEODETIC MEASURES.

Assuming the figure of the earth to be that of an elliptic spheroid of revolution, the magnitude and ratio of its equatorial and polar diameters may be determined from the comparison of the lengths of lines measured between determined points on its surface, with the corresponding arcs of the celestial sphere, by means of theorems which we shall now proceed to demonstrate.

1. *To express the radius of curvature of a meridian in terms of the latitude.*

Let PDQ (fig. 10) be the meridian, CP half the polar axis, CQ the radius of the equator, DM a perpendicular to the tangent at D, meeting CP in M, and CQ in N; and let

a = CP half the polar axis,
b = CQ the radius of the equator,
n = DN the normal at D,
r = radius of curvature at D.

Join CD; let CD′ be the diameter conjugate to CD, meeting DM in G; and through D draw DE and DF respectively perpendicular to CP and CQ. It is demonstrated in the article Conic Sections (Part IV. Sec. 2, Prop. V. Cor. I.), that $r \times \mathrm{DG} = \mathrm{CD}'^2$; and (Prop. XVII. Part II.) $\mathrm{CD}' \times \mathrm{DG} = \mathrm{CP} \times \mathrm{CQ} = ab$; whence $\mathrm{CD}'^2 = a^2 b^2 \div \mathrm{DG}^2$; and consequently $r \times \mathrm{DG}^3 = a^2 b^2$. But (Prop. XXI. Part II.) $\mathrm{DN} \times \mathrm{DG} = \mathrm{CP}^2$; that is, $n \times \mathrm{DG} = a^2$; whence $n^3 \times \mathrm{DG}^3 = a^6$, and therefore $\mathrm{DG}^3 = a^6 \div n^3$, consequently

$$r = \frac{b^2 n^3}{a^4} \quad \text{(1.)}$$

Again (Prop. XXI. Part II.) $\mathrm{DN} : \mathrm{DM} = a^2 : b^2$; and the triangles NCM, NFD being similar, DN : DM = NF : CF, whence $\mathrm{CF} = \frac{b^2}{a^2}\mathrm{NF}$. Now let the angle DNF or the latitude of D $= l$; then DF $= n \sin. l$, NF $= n \cos. l$, and CF $= \frac{b^2}{a^2} n \cos. l$. But DF = CE $= x$ and CF $= y$; substituting therefore $n \sin. l$ for x, and $\frac{b^2}{a^2} n \cos. l$ for y in the equation of the ellipse, namely,

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1,$$

we find

$$\frac{n^2 \sin.^2 l}{a^2} + \frac{b^2 n^2 \cos.^2 l}{a^4} = 1,$$

whence

$$n^2 = \frac{a^4}{a^2 \sin.^2 l + b^2 \cos.^2 l}.$$

Let $b = a(1 + e)$ (e denoting the ellipticity or the ratio of the difference of the semiaxes to the polar semiaxis, that is, $e = \frac{b - a}{a}$; by substituting, we get

$$n^2 = \frac{a^2}{\sin.^2 l + (1 + e)^2 \cos.^2 l};$$

but since the ellipticity e is very small, all terms multiplied by the square or higher powers of e may be rejected without sensible error. Hence $(1 + e)^2 = 1 + 2e$, and therefore $n^2 = \frac{a^2}{1 + 2e \cos.^2 l}$, or $n = a(1 + 2e \cos.^2 l)^{-\frac{1}{2}}$;

whence, on developing and rejecting terms containing e^2,

$$n = a(1 - e \cos.^2 l) \quad \text{(2.)}$$

Now, from equation (1), $r = \frac{b^2}{a^4} n^3 = \frac{1 + 2e}{a^2} n^3$; and from equation (2), $n^3 = a^3(1 - 3e \cos.^2 l)$; therefore $r = a(1 + 2e)(1 - 3e \cos.^2 l) = a(1 + 2e - 3e \cos.^2 l)$; or, finally,

$$r = a(1 - e + 3e \sin.^2 l) \quad \text{(3.)}$$

2. *To express the radius of a circle parallel to the equator in terms of the latitude.*

Suppose the parallel to pass through D, then DE $= y$ is the radius required. But it was shown in the last Prop. that CF (= DE) $= \frac{b^2}{a^2} n \cos. l$; therefore, substituting $a^2(1 + 2e)$ for b^2, we have $y = n \cos. l (1 + 2e)$. Substituting in this the value of n given by equation (2), we have $y = a \cos. l (1 + 2e)(1 - e \cos.^2 l)$; whence $y = a \cos. l (1 + 2e - e \cos.^2 l)$, or

$$y = a \cos. l (1 + e + e \sin.^2 l) \quad \text{(4.)}$$

3. *To find an expression for the length of an arc of the meridian, in terms of the latitudes of its extreme points.*

If the arc is small, it may be regarded as coinciding with the osculating circle at its middle point. Let z = the arc, and r = the radius of curvature at its middle point; then (z being supposed small) we have $z = r \sin. z$. But $z : \sin. z = 1'' : \sin. 1''$; therefore $\sin. z = z \sin. 1''$, and the length of the arc in feet $= r z \sin. 1''$. Now let l and l' be the latitudes at the extremities of the arc, then $\frac{1}{2}(l + l')$ is the latitude of its middle point; and on substituting for r its value found in equation (3), the expression for the length of a meridional arc, in terms of its extreme latitudes l' and l, is

$$z = a\left\{1 - e + 3e \sin.^2 \tfrac{1}{2}(l + l')\right\}(l' - l) \sin. 1'' \quad \text{(5.)}$$

But if the arc is of considerable extent, this expression will not be sufficiently exact, and it becomes necessary to find by integration the lengths of the arcs from the equator to each extremity of the given arc: the difference of these two will give z itself. At the latitude l, $dz = r dl$; therefore, from equation (3),

$$dz = a(1 - e)\,dl + 3ae \sin.^2 l\,dl,$$

and integrating,

$$z = al - ael + 3\,ae\int \sin.^2 l\, dl.$$

But $\int \sin.^2 l dl = \frac{1}{2} l - \frac{1}{4} \sin. 2\,l$; therefore

$$z = a\left\{ (1 + \tfrac{1}{2} e)\, l - \tfrac{3}{4} e \sin. 2\,l \right\} \ldots\ldots\ldots\ldots\ldots (6.)$$

No constant is necessary, because at the equator z and l vanish together.

Let z' be another arc reckoned from the equator to the point whose latitude is l'; then, similarly,

$$z' = a\left\{ (1 + \tfrac{1}{2} e)\, l' - \tfrac{3}{4} e \sin. 2\,l' \right\};$$

and consequently

$$z' - z = a\left\{ (1 + \tfrac{1}{2} e)(l' - l) - \tfrac{3}{4} e (\sin. 2\,l' - \sin. 2\,l) \right\};$$

but $\sin. 2\,l' - \sin. 2\,l = 2 \cos. (l' + l) \sin. (l' - l)$; therefore

$$z' - z = a\left\{ (1 + \tfrac{1}{2} e)(l' - l) - \tfrac{3}{2} e \cos. (l' + l) \sin. (l' - l) \right\},$$

or, as $l' - l$ is expressed in seconds, $z' - z$

$$= a\left\{ (1 + \tfrac{1}{2} e)(l' - l) \sin. 1'' - \tfrac{3}{2} e \cos. (l' + l) \sin. (l' - l) \right\} (7.)$$

4. *To express the length of an arc of parallel in terms of the radius.*

Let $y =$ the radius, D $=$ the amplitude of the arc in seconds, and V $=$ its length in feet. Then, by what is shown above, the length of the arc in feet is yD sin. 1″. Hence, from the value of y given in equation (4), the length of the arc of parallel at latitude l is

$$V = a \cos. l\, (1 + e + e \sin.^2 l)\, D \sin. 1'' \ldots\ldots\ldots (8.)$$

5. *From the measured length of two degrees of meridian at different latitudes, to determine the axis and ellipticity of the spheroid.*

Let Z and Z′ be the measured lengths of two degrees, and the latitudes of their middle points be respectively L and L′; then (since in this case $l' - l = 1° = 3600''$) we have, by equation (5),

$$Z = a\,(1 - e + 3\,e \sin.^2 L)\, 3600 \sin. 1'',$$

$$Z' = a\,(1 - e + 3\,e \sin.^2 L')\, 3600 \sin. 1'',$$

therefore

$$\frac{Z'}{Z} = \frac{1 - e + 3\,e \sin.^2 L'}{1 - e + 3\,e \sin.^2 L};$$

whence, performing the division, and neglecting terms multiplied by e^2,

$$\frac{Z'}{Z} = 1 + 3\,e\,(\sin.^2 L' - \sin.^2 L),$$

from which we find the ellipticity.

$$e = \frac{Z' - Z}{3\,Z\,(\sin.^2 L' - \sin.^2 L)} \ldots\ldots\ldots\ldots\ldots\ldots (9.)$$

The accuracy of this expression will depend on the magnitude of the denominator, or the difference between L′ and L. If L is nearly equal to L′, the denominator becomes very small, and the value of e in consequence uncertain. The most favourable determination, therefore, that can be obtained is, when one of the degrees, Z′, for example, is measured near the pole, and Z at the equator, where L is zero. As an example of this method, we may deduce the value of e from a comparison of the lengths of a degree at the equator and in England. Bouguer found the length of the degree at the equator to be 362,932 English feet; and from the British arc, between Dunnose and Clifton, the length of the degree is 364,970 feet, at the latitude of 52° 35′ 45″. We have therefore Z $=$ 362,932, Z′ $=$ 364,970, L $=$ 0, L′ $=$ 52° 35′ 45″, by substituting which in equation (9), there results

$$e = \frac{2038}{3 \times 362932 \times \sin.^2 (52°\, 35'\, 45'')},$$

whence $e = \dfrac{1}{346}$.

Having found the value of e, that of the polar semi-diameter, or a, is obtained as follows. At the equator, where L vanishes, we have $Z = a (1 - e)\, 3600 \sin.''$, whence

$$a = \frac{Z}{(1 - e)\, 3600 \sin. 1''} = \frac{Z \times 346}{345 \times 3600 \sin.''};$$

and substituting 362,932 for Z, we find

$$a = 20{,}855{,}000 \text{ feet nearly.}$$

The method of deducing the ellipticity and dimensions of the earth which has now been explained, may be conveniently employed when the measured arcs are small; but when the arcs are considerable (and it is necessary that they should extend over several degrees, in order to give results deserving of confidence), we must employ the more accurate expression of the arc found in equation (7); that is to say, we must employ the whole arc measured, instead of the resulting length of a single degree. Equation (7), when reduced to numbers, takes the form

$$A = am + aen \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10.)$$

in which m, n, and the arc A, are numbers determined by observation. Another arc will give a similar equation,

$$A' = am' + aen',$$

and by combining the two equations we get

$$e = \frac{Am' - A'm}{A'n - An'};\quad a = \frac{An' - A'n}{mn' - m'n} \ldots\ldots\ldots\ldots\ldots\ldots (11.)$$

If the terrestrial meridian were a regular ellipse, the ellipticity deduced from two measured arcs would be the same at every latitude. But it is found that no two different measures that have yet been effected concur in giving exactly the same figure to the meridian. Hence it becomes necessary to seek the most probable mean among the different results. Each new measure affords a new equation of condition, of the form of equation (10); and as the number of unknown quantities remains the same, whatever may be the number of equations, recourse must be had to the method of least squares, or some of the other methods of combination employed by astronomers. In this way each individual measurement serves to correct the results given by the former ones.

6. *From the measured lengths of an arc of meridian, and an arc of parallel, to determine the ellipticity of the spheroid.*

Let z be the arc of meridian between the latitudes l and l', V the length of the arc of parallel in feet at the latitude L, and D the difference of longitude in seconds between its extreme points. From equation (5) we have

$$z = a\left\{ 1 - e + 3\,e \sin.^2 \tfrac{1}{2}(l' + l) \right\} (l' - l) \sin. 1'',$$

and from equation (8),

$$V = a\,(1 + e + e \sin.^2 L) \cos. L \times D \sin. 1'',$$

whence

$$\frac{V}{\cos. L \times D \sin. 1''} - \frac{z}{(l' - l) \sin. 1''}$$

$$= ae\left\{ 2 + \sin.^2 L - 3 \sin.^2 \tfrac{1}{2}(l' + l) \right\},$$

and, consequently,

$$e = \frac{\dfrac{V}{\cos. L \times D \sin. 1''} - \dfrac{z}{(l' - l) \sin. 1''}}{a\left\{ 2 + \sin.^2 L - 3 \sin.^2 \tfrac{1}{2}(l' + l) \right\}} \ldots\ldots\ldots\ldots (12.)$$

When the two arcs have been measured at the same

latitude, that is, when $L = \frac{1}{2}(l' + l)$, the denominator of this fraction becomes $a\,(2 - 2\sin.^2 L) = 2\,a\cos.^2 L$. This combination may be considered as giving a correct representation of the curvature at any particular place, or of the dimensions and eccentricity of the osculating spheroid at that place. But, speaking generally, the exact determination of the differences of longitude is attended with so much uncertainty, that the results obtained from the comparison of arcs of parallel, either with one another or with arcs of meridian, cannot be relied on with much confidence. It is consequently unnecessary to point out the equations to be employed in deducing the ellipticity from the comparison of two arcs of parallel.

We shall now proceed to apply the above formulas to the results of the principal geodetic measurements that have been executed in different countries. The following table contains twenty arcs of meridian, between the equator and 66° of north latitude; and as they have all been determined with the utmost attention to every circumstance which could be supposed to affect their accuracy, they may be regarded as decidedly the best elements we yet possess for the solution of the problem of the figure of the earth. We have excluded all the ancient arcs except that of Bouguer, and also some recent ones, where the locality was unfavourable. They are all reduced to the level of the sea. In reducing the foreign measures, the metre has been assumed (according to Captain Kater's determination) = 3·280899 feet, and the toise = 6·394596 feet, of Schuckburgh's scale. The original documents are given in the various works to which reference has been made in the first section of this article.

No.	Extremities of Arc.	Latitude.	Amplitude.	Length in English Feet.
	PERUVIAN ARC.			
1	Tarqui	— 3° 4′ 32″·07	3° 7′ 3″·5	1,131,057
	Cotchesqui	+ 0 2 31·39		
	1ST INDIAN ARC.			
2	Trivandeporum	+ 11 44 52·59	1 34 56·4	574,318
	Paudree	13 19 49·02		
	2D INDIAN ARCS.			
3	Punnæ	+ 8 9 32·51	2 50 10·5	1,029,171
4	Putchapolliam	10 59 43·05	4 6 11·3	1,489,198
5	Namthabad	15 5 54·33	2 57 21·7	1,073,409
6	Daumergidda*	18 3 16·07	3 2 35·9	1,105,499
7	Takal Khera	21 5 51·94	3 1 19·9	1,097,320
	Kullianpoor*	24 7 11·85		
	Kaliana	29 30 48·90	5 23 37·05	1,961,157·1
	MODERN FRENCH ARCS.			
8	Formentera	+ 38 39 56·11	2 41 50·5	982,247
9	Montjouy	41 21 46·58	1 51 7·7	674,623
10	Carcassone	43 12 54·31	2 57 48·2	1,079,706
11	Evaux	46 10 42·54	2 40 6·8	973,853
12	Pantheon	48 50 49·37	2 11 19·1	798,971
13	Dunkirk	51 2 8·50	0 26 31·5	161,412
	Greenwich	51 28 40·00		
	ENGLISH ARCS.			
14	Dunnose	+ 50 37 8·60	1 36 20·0	586,319
15	Arbury Hill	52 13 28·59	1 14 3·4	450,018
16	Clifton	53 27 31·99	1 6 49·7	406,516
	Burleigh Moor	54 34 21·70		
	HANOVERIAN ARC.			
17	Göttingen	+ 51 31 47·85	2 0 57·4	736,426
	Altona	53 32 45·27		
	RUSSIAN ARCS.			
18	Jacobstadt	+ 56 30 4·64	1 52 42·8	686,022
19	Dorpat	58 22 47·41	1 42 22·5	623,719
	Hochland	60 5 9·90		
	SVANBERG'S SWEDISH ARC.			
20	Mallörn	+ 65 31 31·06	1 37 20·3	593,278
	Pahtawara	67 8 51·41		

* On remeasurement by Colonel Everest, the arc from Damergidda to Kalianpoor was found to embrace an amplitude of 6° 3′ 55″·97, and a length of 2202926·2 feet. (1855.)

Substituting in equation (7) the values of $z'-z$, l, and l', for each of the arcs in the above table, we obtain the following equations of condition:

1. $a \times \cdot 0544111 - ae \times \cdot 05426 = 1131057$
2. $a \times \cdot 0276169 - ae \times \cdot 02371 = 574368$
3. $a \times \cdot 0495037 - ae \times \cdot 04536 = 1029171$
4. $a \times \cdot 0716119 - ae \times \cdot 06058 = 1489198$
5. $a \times \cdot 0515924 - ae \times \cdot 03891 = 1073409$
6. $a \times \cdot 0531157 - ae \times \cdot 03519 = 1105499$
7. $a \times \cdot 0527472 - ae \times \cdot 02933 = 1097320$
8. $a \times \cdot 0470778 + ae \times \cdot 01131 = 982247$
9. $a \times \cdot 0323260 + ae \times \cdot 01159 = 674623$
10. $a \times \cdot 0517210 + ae \times \cdot 02504 = 1079706$
11. $a \times \cdot 0465751 + ae \times \cdot 02940 = 973853$
12. $a \times \cdot 0381990 + ae \times \cdot 02893 = 798971$
13. $a \times \cdot 0077158 + ae \times \cdot 00636 = 161412$
14. $a \times \cdot 0280221 + ae \times \cdot 02335 = 586319$
15. $a \times \cdot 0215422 + ae \times \cdot 01900 = 450018$
16. $a \times \cdot 0194397 + ae \times \cdot 01875 = 406516$
17. $a \times \cdot 0351849 + ae \times \cdot 03132 = 736426$
18. $a \times \cdot 0327868 + ae \times \cdot 03708 = 686022$
19. $a \times \cdot 0297797 + ae \times \cdot 03618 = 623719$
20. $a \times \cdot 0283097 + ae \times \cdot 04293 = 593278$

From any two of these equations we may deduce values of a and e; but, as might be expected, the results are found to be very different according as different arcs are selected for comparison. We may also add any number of the equations together, for instance Nos. 3, 4, 5, 6, and 7, the sum of which forms the continuous arc measured in India by Colonel Lambton and Captain Everest: or Nos. 8, 9, 10, 11, and 12, which form the French arc from Dunkirk to Formentera. But as it is impossible to satisfy at once all the equations by any value whatever that can be assigned to a and e, in order to exclude all arbitrary hypotheses, it is necessary to suppose all the observations to have been alike good, and deduce values of a and e from a combination of the whole. The best method of effecting the combination is that of *minimum squares*, the principle of which is contained in the following rule: Multiply all the terms of each of the proposed equations by the co-efficient of a in that equation, taken with its proper sign, and make the sum of all the products equal to zero. This will give an equation in which the sum of the squares of the errors is a minimum in respect of a. Multiply then each equation by the co-efficient of ae in that equation, and make the sum of all the products $= 0$. This will give a second equation, in which the sum of the squares of the errors is a minimum in respect of ae. From the two equations thus obtained, the values of a and ae, and consequently e, are found in the usual manner. The operation is extremely laborious when the equations are numerous, but it is attended with no difficulty.

By combining the above twenty equations in the manner now described, M. Schmidt obtained the following results, which are given in No. 213 of Schumacher's *Astronomische Nachrichten*, p. 371; and they are unquestionably entitled to be regarded as the best determination of the magnitude and figure of the earth which has been found from the operations that have been undertaken up to the present time for the measurement of meridional arcs.

Radius of equator $= b = 20921665$ Eng. feet.

Radius of pole..... $= a = 20852394$

$$\text{Ellipticity} = e = \frac{b-a}{a} = \frac{1}{301\cdot 02} = \cdot 0032555$$

Degree at equator...... $= 362732$

Degree at latitude 45° $= 364543\cdot 5$

In order to discover how nearly the different measures agree with a spheroid having the dimensions now given, we shall compare the length of a degree, as given by each of the above twenty arcs, with its length, computed from these values of a and e at the same latitudes.

No.	Latitude of Middle Point.	Measured Length of Degree.	Computed Length of Degree.	Error in Measure.
1	—1° 31′ 0″	362,809	362,736	+ 73
2	12 32 21	362,988	362,905	+ 83
3	9 34 43	362,863	362,834	+ 29
4	13 2 54	362,873	362,919	— 46
5	16 34 42	363,125	363,029	+ 96
6	19 34 34	363,257	363,139	+ 118
7	22 36 32	363,084	363,268	— 184
8	40 0 52	364,152	364,233	— 81
9	42 17 21	364,239	364,376	— 137
10	44 41 48	364,347	364,528	— 181
11	47 30 46	364,962	364,706	+ 256
12	49 56 29	365,052	364,859	+ 193
13	51 15 24	365,116	364,940	+ 176
14	51 25 18	365,208	364,952	+ 256
15	52 50 30	364,625	365,036	— 411
16	54 0 56	365,002	365,109	— 107
17	52 32 17	365,301	365,019	+ 282
18	57 26 26	365,203	365,310	— 107
19	59 13 58	365,551	365,412	+ 139
20	66 20 11	365,697	365,777	— 80

From this table we see that the degrees increase gradually from the equator to the pole; but the increase is by no means regular. It occurs in some instances that the degrees appear to diminish on going northward; but these anomalies must be ascribed either to errors in the observations or to local irregularity of form or density. The most probable source of error is in the latitudes, first, on account of the difficulty of the observation to the requisite degree of accuracy; and, secondly, on account of the irregularities in the density of the exterior crust of the earth, which cause a deflexion of the plumb-line from the true zenith. Hence the longest arcs are the best; for the probable error in the determination of the difference of latitudes is the same whether the arcs are great or small. An error of 1″ in the latitude corresponds to about a hundred feet on the ground.

If we compare the degree found by some of the measures which have been rejected from the foregoing table, with the degree computed for the same latitudes, we shall find the errors or anomalies much greater.

Arcs.	Lat. of Middle Point.	Measured Length of Degree.	Computed Length of Degree.	Difference.
Lacaille's arc at Cape of Good Hope	—33° 18′ 30″	364,712	363,826	+ 886
North American arc, by Mason and Dixon	39 12 00	363,786	364,181	— 395
Roman arc, by Boscovich	42 59 00	364,262	364,418	— 156
Piedmontese arc, by Plana and Carlini	44 57 30	368,242	364,543	+ 3699
Maupertuis' Swedish arc	66 19 37	367,086	365,774	+ 1312

Figure of the Earth.

Two of these differences are considerably greater than any in the preceding table. Lacaille's arc corresponds to one in the northern hemisphere at a higher latitude by 14°, whence it has been inferred that the two hemispheres are not exactly similar. The measurement of Plana and Carlini appears to have been excellent; but both extremities of the arc were in the immediate vicinity of lofty mountain ranges, and the very great deviation from the mean result of the other measures can only be accounted for by the disturbing effects of local attraction. Maupertuis' arc was never reckoned of much value, as it was evident from the first that there was an error in the determination of the latitudes.

Taking the results of the four arcs of parallel mentioned before, and computing the corresponding degree from the formula $a \cos. l\,(1 + e + e \sin.^2 l)\ 3600 \sin. 1''$ (supposing a and e to have the same values as above), we get the following table:

Arcs of Parallel.	Latitude.	Measured Degree.	Computed Degree.	Difference.
Lacaille's arc across the mouth of the Rhone..............	43° 31′ 50″	266,345	265,154	+ 1191
Roy's arc from Beachy Head to Dunnose....................	50 44 24	232,331	231,542	+ 789
Arc from Dover to Falmouth......................................	50 44 24	231,579	231,542	+ 37
Arc from Padua to Marennes....................................	45 43 12	255,480	255,370	+ 110

It is remarkable that all these errors are affected with the same sign; and the circumstance might seem to strengthen a conclusion indicated by a comparison of the errors of the meridional arcs, namely, that the meridional curve is not exactly an ellipse, but protuberant between the latitudes of 40° and 52°; in consequence of which the degrees of meridian are shorter, and the degrees of parallel longer between those latitudes, than if the earth were a regular ellipsoid. There is no reason to infer that the meridians are not similar, or that the earth is not a solid of revolution.

The six partial arcs into which the whole arc from Marennes to Padua was divided, give the following results (*Connaissance des Tems*, 1829).

	Arcs.	Astronomical Amplitudes. h. m. sec.	Length in Feet.	Length of Degree.
1	Marennes to St Preuil..	0 3 48·99	244,123	255,865
2	St Preuil to Sauvagnac..	0 6 23·09	407,429	255,248
3	Sauvagnac to Isson...	0 6 51·39	437,493	255,228
4	Isson to Geneva..	0 11 57·82	764,736	255,686
5	Geneva to Milan..	0 12 9·57	776,646	255,486
6	Milan to Padua..	0 10 45·38	686,549	255,308

The mean of these results, or the most probable value of the degree of parallel at the latitude of the stations (45° 43′ 12″), is 255,470 feet, exceeding the computed length only by a hundred feet; and the ellipticity which they indicate is $\frac{1}{282\cdot8}$. This is considerably greater than the ellipticity indicated by the measures of meridional arcs, but agrees pretty nearly with that which we shall see is given by the pendulum observations. The results, however, though valuable as confirming the results obtained by other methods, are not by any means worthy of the same confidence as those deduced from the measurement of meridional arcs.

We shall conclude this section with a re-statement of the dimensions of the earth, resulting from the principal measures of arcs of meridian.

		Feet.		Miles.
Equatorial diameter.............	=	41843330	=	7924·873
Polar diameter.....................	=	41704788	=	7898·634
Difference of diameters, or polar compression...........	=	138542	=	26·239
Ratio of diameters...............	=	302·026	:	301·026

$$\text{Ellipticity} = \frac{b-a}{a} = \frac{1}{301\cdot026}$$

Length of degree at equator = 362732 feet.
Length of degree at lat. 45° = 364543·5 feet.

SECTION IV.

THEORETICAL INVESTIGATION OF THE FIGURE OF THE EARTH FROM THE LAWS OF HYDROSTATICS.

In attempting to deduce the figure of the earth from the general laws of hydrostatic equilibrium, we suppose the whole mass to have been originally fluid, or in such a state, that all its molecules were at liberty to obey the forces by which they are impelled. These forces are, 1*st*, the attraction of the molecules on one another, according to the Newtonian law; and, 2*dly*, the centrifugal force generated by the revolution of the whole mass about a fixed axis; and the problem is, to determine the form which such a body, under the influence of these forces, would ultimately take. In order to obtain a solution of the question thus generally enunciated, it is necessary to know, *a priori*, the attractions of the different parts of the fluid body on one another. But the attraction of its different parts depends on their mutual arrangement; that is to say, on the internal constitution of the body or the variations of its density, and also on its form. Of the density in the interior of the earth we know little; and its form is the very element we are seeking to determine. This mutual dependence of the attraction of the mass on its form, and of its form on its attraction, renders it necessary to have recourse to certain arbitrary assumptions respecting the primitive figure of the earth and its internal structure, in order to deter-

mine the relation of the forces with which its different parts attract each other, and thence assign its figure, and the variations of gravity at the different points of its surface.

A fluid mass whose particles are impelled by no other forces than those which result from their mutual attractions, would assume (it is natural to suppose) a spherical form. Such at least would be a figure of equilibrium; for the surface of the sphere being everywhere at right angles to the directions of the attracting forces, which in this case all pass through the centre of gravity, a particle placed on its surface would have no tendency to move along the surface in any direction. But if the mass is made to revolve, the rotation gives rise to an extraneous force, tending to cause every particle to recede from the axis, and which acts with an energy on each particle directly proportional to the distance of the particle from the axis. Hence the attraction of the mass on each particle, in the direction perpendicular to the axis of rotation, is diminished, and the diminution is greatest towards the equatorial parts, where the distance from the axis is greatest. In order, therefore, that the equilibrium may be restored, an accumulation of matter must take place about the equator, so that the mass will bulge out in that quarter, and become flattened at the poles, where the force of attraction is not counteracted. This consideration led Newton to suppose the figure of the earth to be that of an oblate spheroid, or the figure that is generated by the revolution of an ellipse about its shorter axis.

Before proceeding with the investigation, it will be proper to inquire what are the conditions necessary to ensure the equilibrium of a mass of fluid matter, the particles of which are acted on by their mutual attractions and the centrifugal force of rotation. Conceive the particles of a body A to be solicited by accelerating forces of any kind. Suppose dm (which may be regarded as a rectangular parallelepipedon, having its faces parallel to the planes of the co-ordinates) to be one of the molecules of the mass, and x, y, z, the co-ordinates of the solid angle nearest the origin; then, putting $k =$ the density of the mass, we shall have $dm = k \,.\, dx\, dy\, dz$. Let X, Y, Z be the accelerating forces acting on dm in the direction parallel to the respective axes of the co-ordinates, then the motive forces in the direction of the same axes will be respectively $\mathrm{X}dm$, $\mathrm{Y}dm$, $\mathrm{Z}dm$.

Now let $p =$ the pressure in the direction of the axis of x, referred to the unit of surface; then $p \,.\, dydz$ is the whole pressure on the face $dydz$ of the element dm. But p may be regarded as a function of x, y, z; therefore at the point whose co-ordinates are $x + dx, y, z$, the pressure on the unit of surface is $p + \frac{dp}{dx} dx$, and consequently the whole pressure on the face of dm opposite to $dxdy$ is $\left(p + \frac{dp}{dx} dx\right) dydz$. The particle dm is thus urged in the direction of the axis of x by the two forces $p \,.\, dydz$ and $\left(p + \frac{dp}{dx} dx\right) dydz$, or by a force equal to their difference, namely, $\frac{dp}{dx} dxdydz$. In order, therefore, that dm may remain at rest, this last force or pressure must be exactly balanced by the motive force acting in the direction of the same axis; that is to say, we must have $\frac{dp}{dx} dxdydz = \mathrm{X}dm$ In the same manner, we must have $\frac{dp}{dy} dxdydz = \mathrm{Y}dm$, and $\frac{dp}{dz} dxdydz = \mathrm{Z}dm$; whence, since $dm = k \,.\, dx\, dy\, dz$, we deduce

$$\frac{dp}{dx} = k\mathrm{X},\ \frac{dp}{dy} = k\mathrm{Y},\ \frac{dp}{dz} = k\mathrm{Z} \ldots\ldots\ldots\ldots (a).$$

Let the first of these equations be multiplied by dx, the second by dy, and the third by dz, the sum of the products gives

$$dp = k\,(\mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz) \ldots\ldots\ldots\ldots\ldots (b).$$

The first member of this equation being an exact differential, it is necessary, in order that the equilibrium be possible, that the second member be an exact differential likewise. This, therefore, is a condition which must be satisfied.

At the surface of the mass the pressure p vanishes, and equation (b) becomes

$$0 = k\,(\mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz),$$

which expresses that the resultant of the three forces X, Y, Z, is perpendicular to the surface.

If the fluid is homogeneous, the density k is constant, and may be represented by unit. In this case equation (b) becomes

$$dp = \mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz,$$

and the equation of the surface is

$$\int (\mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz) = \text{constant.}$$

It will be remarked that this last equation does not belong merely to the exterior surface or to the homogeneous fluid: by giving a different value to the constant it will form the equation of any surface in the interior of a mass of heterogeneous fluid, at every point of which the pressure or the density is the same. For let the second member of equation (b) be a complete differential, and equal to kdf. We have then $dp = kdf$, whence k is necessarily a function of p and f. But on integrating the equation, f will be given in a function of p, consequently k must be a function of p. When therefore k is constant, p must be constant, or $dp = 0$; hence

$$\int (\mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz) = \text{constant.}$$

The different surfaces defined by this equation all possess the common property of intersecting at every point the resultant of the accelerating forces X, Y, Z at right angles; hence they are denominated *level surfaces.*

It follows, therefore, that when the above equation is satisfied, two conditions necessary to the equilibrium are fulfilled; namely, that the resultant of all the forces urging any particle in the interior of the mass is perpendicular to the level surface passing through that particle; and that the force acting on any particle of the surface is perpendicular to the surface. When the fluid is homogeneous, or the density equal throughout the mass, the first of these conditions is always satisfied, and the second is of itself sufficient. Writers on this subject have therefore in general considered that all the conditions necessary to ensure the equilibrium of a fluid mass, whether homogeneous or heterogeneous, revolving about a fixed axis, are comprehended in the single equation

$$\int (\mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz) = \text{constant};$$

and this is the view which has been taken of the question by Clairaut, D'Alembert, Lagrange, Laplace, Legendre, and Poisson. It has, however, been demonstrated by Mr Ivory, in an elaborate paper in the *Philosophical Transactions for* 1824, that when, as in the case of the earth, a mutual attraction exists among the constituent molecules of the mass, another condition must be fulfilled; and that the equilibrium will not necessarily take place, unless the figure of the mass is such, that any "interior body of the fluid, bounded by a level surface, be *in equili-*

brio with respect to the attraction of all the exterior matter." Hence, in addition to the equation derived from the principle of equal pressure in all directions, a second equation must be satisfied, in virtue of which every level stratum must possess such a figure as to attract all particles in the inside with equal force in opposite directions. Without having regard to this condition, the problem cannot be completely solved. (See also *Philosophical Magazine* for April 1825.)

Within the limits to which the present article must necessarily be confined, it would be in vain to attempt to give a general solution of this very intricate problem. We shall therefore content ourselves with demonstrating that all the conditions of equilibrium will be satisfied, if the figure of the earth (assumed to be fluid) is that of a spheroid of revolution of small ellipticity. We shall, first, suppose the fluid to be homogeneous; and, secondly, that its density is variable.

Prop. I.—A particle placed anywhere within a hollow solid of homogeneous matter, generated by the annular space comprised between two similar and similarly situated concentric ellipses revolving about their common axis, is attracted by the solid equally in all directions.

For let p (fig. 11) be such a particle, and ab any straight line passing through p, meeting the exterior surface in a and b, and the interior in c and d; then if ab be bisected in e, cd will also be bisected in e, because the figures are similar and similarly situated. Therefore $ac = db$. Now conceive ab to be the axis of two opposite pyramids having their vertices at p, and terminated by the surface at a and b, and let mn be an infinitely thin slice of the pyramid ab, formed by surfaces parallel to that of the given spheroid. The attraction of mn on p is directly as the surface mn and inversely as pm^2; but the surface mn is proportional to pm^2; therefore the attraction of p on the pyramidal slice mn is constant; hence the attraction of p on the whole frustum between a and c is proportional to the number of such slices, or to ac. In the same manner the attraction of p on the frustum between d and b is proportional to db. But $ac = db$; therefore p is attracted equally in both directions. The same thing being true of all other pyramids which have their vertices at p, it follows that the particle p is attracted equally in all directions, or remains at rest.

This property, which is true also of the sphere, and forms one of the necessary conditions of equilibrium, was first demonstrated by Newton in the *Principia*.

Prop. II.—To find the ratio of the axes of a homogeneous spheroid of revolution, when a fluid column from the equator to the centre balances the column from the pole to the centre, the spheroid being supposed to revolve about its minor axis, and its particles to attract one another with forces varying in the inverse ratio of their mutual distances.

Let PQ (fig. 12) be a meridian of the spheroid, of which the centre is C. Let us assume in the following propositions,

$P =$ the attraction of the spheroid at the pole, or gravity,
$Q =$ the attraction at the equator,
$\varphi =$ the centrifugal force at the equator,
$Q' = Q - \varphi$ the gravitation at the equator, or the attraction of the spheroid there diminished by the centrifugal force.

Let also

$a =$ CP half the polar axis,
$b =$ CQ the radius of the equator.

In CP take any point E, and make CE $= x$. It is demonstrated in the article Attraction (art. 8), that the force with which a particle at E is attracted towards C, is to that with which a particle at P is attracted in the same direction as CE to CP, or x to a; therefore the force at E $= P \cdot \frac{x}{a}$. Now if we suppose the area of a section of the column perpendicular to the axis $= 1$, the mass of the element of the column will be $1 \times dx = dx$, and its pressure will consequently be $P \frac{x}{a} dx$. Let this quantity be represented by du. On integrating, and observing that while x increases u diminishes, we find

$$u = \text{const.} - P \cdot \frac{x^2}{2a}.$$

At the surface $u = 0$ and $x = a$; therefore

$$0 = \text{const.} - P \cdot \frac{a^2}{2a};$$

whence, by subtraction, $u = P \cdot \frac{a^2 - x^2}{2a}$,

and consequently at the centre, where $x = 0$, $u = P \cdot \frac{a}{2}$.

In like manner, if in CQ we take a point F, and make CF $= y$, the force at F resulting from the attraction of the spheroid will be $Q \cdot \frac{y}{b}$. But the centrifugal force at F is to that at Q as CF to CQ, or as y to b; therefore the centrifugal force at F $= \varphi \cdot \frac{y}{b}$. Hence the force with which a particle at F is attracted towards the centre is $(Q - \varphi) \frac{y}{b}$ $= Q' \frac{y}{b}$, and the pressure of the element of the column $= Q' \frac{y}{b} dy$. Putting this $= du'$, and integrating as before, we find, at the centre, $u' = Q' \frac{b}{2}$. But, by hypothesis, at the centre $u' = u$; therefore $P \frac{a}{2} = Q' \frac{b}{2}$, whence $P : Q' = b : a$; that is to say, the attraction at the pole is to the gravitation at the equator as the radius of the equator to the radius of the pole.

Prop. III.—If the radius of the equator is to the radius of the pole as the attraction at the pole is to the gravitation at the equator, the resultant of all the forces which urge a particle situated any where on the surface of the spheroid is perpendicular to the surface.

Let D (fig. 10) be the particle, and PDQ the meridian passing through it. As the plane of the meridian divides the solid into two parts exactly alike in every respect, it is obvious that the particle can have no tendency to move out of that plane; we shall therefore only consider the direction of the force urging it in the plane of the meridian. Let DE be perpendicular to CP, and DF to CQ; and make CE $= x$, CF $= y$. It is demonstrated in the article Attraction (21 and 22), that the force which attracts D in the direction DF, perpendicular to the plane of the equator, is to the force at the pole as DF to CP, or as $x : a$; and that the force attracting D in the direction DE perpendicular to the axis is to the attraction at Q as DE to CQ, or as $y : b$; but the centrifugal force at D, which also acts in the direction DE, is to that at Q as DE to CQ; therefore, taking X to represent the whole force at D in the direction parallel to the axis, and Y that in the direction perpendicular to the axis, we have

$$X : P = x : a, \text{ and } Y : Q' = y : b,$$

 whence $X = P\frac{x}{a}$, $Y = Q'\frac{y}{b}$. In QC take the point N such that FN : FD = Y : X; then FN : FD $= Q'\frac{y}{b} : P\frac{x}{a}$, or FN $\cdot x$: FD $\cdot y$ = $Q'a : Pb$, whence, since FD = x, and FC = y, FN : FC = $Q'a : Pb$. But by hypothesis $Q' : P = a : b$, therefore FN : FC = $a^2 : b^2$, whence by the well-known properties of the ellipse FN is the subnormal, and DN the normal or perpendicular to the surface of the spheroid at D.

Corollary. If the attraction at the pole is represented by CP, then the force at any point D on the surface, in the direction perpendicular to the surface, is proportional to DN the normal passing through D. It is also proportional to DM (the normal produced till it meets the axis); for, by conic sections, DM : DN = $b^2 : a^2$; that is, DM has to DN a constant ratio.

The proposition which has now been demonstrated is sufficient for the equilibrium of a homogeneous fluid mass revolving about an axis. It may, however, be shown directly, that when the above condition is fulfilled, any particle in the interior of the mass will be equally urged in all directions, or will remain at rest. Thus:—

Prop. IV.—If the radius of the equator is to the radius of the pole as the attracting force at the pole is to gravitation at the equator, the pressure which any point D in the interior of the spheroid sustains from the fluid in canals of any form, extending from that point to the surface, is the same for every canal.

Let DD'd (fig. 13) be a canal drawn from any point D in the interior of the spheroid to D' and d in the surface. Let x', y', z' be the rectangular co-ordinates of D, and x'', y'', z'' those of D'. Take F and f, any two points in the canal indefinitely near each other, and let x, y, z be the co-ordinates of F; then $x + dx$, $y + dy$, and $z + dz$ are those of f. Now X, Y, and Z being the resultants of the forces acting on F in the directions of the co-ordinates, the forces X, Y, Z will be reduced to the direction of the canal at F by multiplying them respectively by the cosines of the angles which that direction makes with the axes, that is, by $\frac{dx}{du}$, $\frac{dy}{du}$, $\frac{dz}{du}$, (u representing the canal). Hence the accelerating force acting on F in the direction of the canal is $X\frac{dx}{du} + Y\frac{dy}{du} + Z\frac{dz}{du}$; and supposing the area of a section of the canal = 1, the pressure produced by the action of this force on the fluid contained in the portion of the canal Ff is $du\left(X\frac{dx}{du} + Y\frac{dy}{du} + Z\frac{dz}{du}\right)$. But, by what has been demonstrated in the article Attraction (9), $X = P\frac{x}{a}$, $Y = Q'\frac{y}{b}$, $Z = Q'\frac{z}{b}$; therefore, denoting the whole pressure of the canal on F by p, and observing that p diminishes as F is nearer the surface, we have

$$-dp = du\left(P\frac{x}{a}\cdot\frac{dx}{du} + Q'\frac{y}{b}\cdot\frac{dy}{du} + Q'\frac{z}{b}\frac{dz}{du}\right),$$

and integrating,

$$p = \text{const.} - P\frac{x^2}{2a} - Q'\frac{y^2 + z^2}{2b}$$

At the point D this becomes

$$p = \text{const.} - P\frac{x'^2}{2a} - Q'\frac{y'^2 + z'^2}{2b},$$

and at D', where $p = 0$,

$$0 = \text{const.} - P\frac{x''^2}{2a} - Q'\frac{y''^2 + z''^2}{2b};$$

therefore, by subtraction,

$$p = P\frac{x''^2 - x'^2}{2a} + Q'\frac{y''^2 - y'^2 + z''^2 - z'^2}{2b}.$$

Now the equation of the surface of the spheroid gives

$$x''^2 = \frac{a^2}{b^2}\left\{b^2 - (y''^2 + z''^2)\right\},$$

whence

$$P\frac{x''^2}{2a} = P\frac{a}{2} - P\frac{a(y''^2 + z''^2)}{2b^2},$$

and, by hypothesis, $P : Q' = b : a$, or $Pa = Q'b$; therefore

$$P\frac{x''^2}{2a} = P\frac{a}{2} - Q'\frac{y''^2 + z''^2}{2b};$$

and on substituting this in the above expression of the value of p, we get, finally,

$$p = P\frac{a}{2} - P\frac{x'^2}{2a} - Q'\frac{y'^2 + z'^2}{2b}.$$

This equation being independent of the form of the canal, and of the situation of the point D', will necessarily be the same for every canal extending from D to the surface of the spheroid; consequently the point D sustains the same pressure in all directions.

From what has now been demonstrated, it appears that a fluid spheroid of uniform density, revolving about its lesser axis, and whose particles attract one another with forces varying in the inverse ratio of the distances, will be *in equilibrio* when the gravity at the pole is to the gravity at the equator diminished by the centrifugal force there, as the equatorial axis to the polar axis. The equation of equilibrium of such a spheroid is therefore $Pa = Q'b$; and from this we shall now proceed to determine the ratio of the axes, or of $a : b$, corresponding to a given velocity of rotation.

Let ϵ be the eccentricity, that is, let $\epsilon^2 = \frac{b^2 - a^2}{a^2}$, whence $b^2 = a^2(1 + \epsilon^2)$. It is demonstrated in the article Attraction (23 and 24), that

$$P = 4\pi a\frac{1 + \epsilon^2}{\epsilon^3}(\epsilon - \text{arc tan. }\epsilon)$$

$$Q = (Q' + \varphi) = 2\pi b\frac{1 + \epsilon^2}{\epsilon^3}\left(\text{arc tan. }\epsilon - \frac{\epsilon}{1 + \epsilon^2}\right),$$

the density of the mass being 1, and π the semicircumference of a circle whose radius is unit. Now if t denote the time of a revolution, we shall have, from the theory of central forces, $\varphi = \frac{4\pi^2}{t^2}b$; and making $\frac{\pi}{t^2} = m$, we get $\varphi = 4\pi bm$, whence

$$Q' = 2\pi b\left\{\frac{1 + \epsilon^2}{\epsilon^3}\left(\text{arc tan. }\epsilon - \frac{\epsilon}{1 + \epsilon^2}\right) - 2m\right\}.$$

Substituting these values of P and Q' in the equation $Pa = Q'b$, it becomes

$$4\pi a^2\frac{1 + \epsilon^2}{\epsilon^3}(\epsilon - \text{arc tan. }\epsilon) =$$

$$2\pi b^2\left\{\frac{1 + \epsilon^2}{\epsilon^3}\left(\text{arc tan. }\epsilon - \frac{\epsilon}{1 + \epsilon^2}\right) - 2m\right\};$$

whence, putting $a^2(1 + \epsilon^2)$ instead of b^2, and neglecting the common factors, we get

$$\text{arc tan. }\epsilon = \frac{3\epsilon + 2m\epsilon^3}{3 + \epsilon^2}\ldots\ldots\ldots\ldots(1).$$

In order to discover whether this equation, which is transcendental, has a real root, or how many, we may put

$$\beta = \frac{3\epsilon + 2m\epsilon^3}{3 + \epsilon^2} - \text{arc tan. }\epsilon\ldots\ldots\ldots(2),$$

and suppose the curve to be described, of which ϵ is the absciss, and β the ordinate. This curve will evidently cut the axis at the origin of the co-ordinates; for when $\epsilon=0$, we have also $\beta=0$; but the root $\epsilon=0$ has no concern with the question; for the velocity, and consequently ϵ, is supposed to be a real quantity. By changing the sign of ϵ, the value of β undergoes no alteration, whence the curve has two equal and similar branches on opposite sides of the origin; we need therefore attend only to the positive values of ϵ. If then we suppose ϵ to increase from nothing to infinity, the value of β will begin and end with being positive, whence between these two values of ϵ the curve will either not cut the axis at all, or cut it an even number of times; or, which is the same thing, the equation has either no roots, or an equal number.

To find the values of ϵ corresponding to the greatest and least values of β, we must make $d\beta=0$. Differentiating equation (2), we get, after arranging the terms,

$$\frac{d\beta}{d\epsilon}=\frac{2\epsilon^2\{m\epsilon^4+(10m-2)\epsilon^2+9m\}}{(1+\epsilon^2)(3+\epsilon^2)^2};$$

whence, making $d\beta=0$,

$$m\epsilon^4+(10m-2)\epsilon^2+9m=0\ldots\ldots\ldots\ldots\ldots(3),$$

the two roots of which are

$$\epsilon^2=5-\frac{1}{m}\pm\sqrt{\left(5-\frac{1}{m}\right)-9.}$$

Since these are the only roots of equation (3), it follows that there can be only one maximum and one minimum value of the ordinate β on each side of the origin of the abscissa. Hence we infer that the curve intersects the positive abscissa only in two points exclusive of the origin; so that there are two, and only two, real and positive roots of the equation (1). Thus there are two forms of the oblate spheroid, which, for a given velocity of rotation, satisfy the condition of equilibrium; a curious result, which was first made known by Legendre.

The limits within which the roots of equation (1) are possible will be obtained by determining the values of ϵ and m at the point where the curve touches the axis of the abscissa without cutting it. At this point $\beta=0$, and $d\beta=0$. When $d\beta=0$, equation (3) gives

$$m=\frac{2\epsilon^2}{\epsilon^4+10\epsilon^2+9}=\frac{2\epsilon^2}{(1+\epsilon^2)(9+\epsilon^2)}\ldots\ldots\ldots(4);$$

substituting this in (2), and making $\beta=0$, we get, after reduction,

$$\text{arc tan. }\epsilon=\frac{7\epsilon^5+30\epsilon^3+27\epsilon}{(3+\epsilon^2)(1+\epsilon^2)(9+\epsilon^2)},$$

or, dividing the terms by $(3+\epsilon^2)$,

$$\text{arc tan. }\epsilon=\frac{7\epsilon^3+9\epsilon}{(1+\epsilon^2)(9+\epsilon^2)};$$

an equation which can have only one positive root besides $\epsilon=0$. On solving it by approximation we easily find, on a few trials,

$$\epsilon=2\cdot5292;$$

whence, from equation (4), the corresponding value of m is

$$m=0\cdot11234.$$

From this we conclude that, when the value of m is smaller than 0·11234, the equation (1) has two unequal positive roots; that when m is equal to this number, the two roots become equal, or the two intersections of the curve with the axis pass into a contact; and that when m is greater than 0·11234, equation (1) has no real roots, or the equilibrium is impossible.

When the eccentricity ϵ is a very small fraction, as in the case of the earth, the values of the quantities denoted by P and Q may be developed in series proceeding according to the powers of ϵ, and converging rapidly. Because (see ALGEBRA, sect. XXV. (H 2)

$$\text{arc tan. }\epsilon=\epsilon-\frac{\epsilon^3}{3}+\frac{\epsilon^5}{5}-,\ \&\text{c.}$$

and because

$$\frac{\epsilon^2}{1+\epsilon^5}=\epsilon-\epsilon^3+\epsilon^5-,\ \&\text{c.}$$

the preceding expression for P becomes

$$P=4\pi a\,.\,\frac{1+\epsilon^2}{\epsilon^3}\left(\frac{\epsilon^3}{3}-\frac{\epsilon}{5}+\ \&\text{c.}\right);$$

whence, on multiplying, and rejecting all terms involving higher powers of ϵ than the square,

$$P=4\pi a\left(\frac{1}{3}+\frac{2}{15}\epsilon^2\right)=\frac{4\pi a}{3}\left(1+\frac{2}{5}\epsilon^2\right).$$

Making the same substitutions in the value of Q, we find

$$Q=2\pi b\,\frac{1+\epsilon^2}{\epsilon^3}\left(\frac{2}{3}\epsilon^3-\frac{4}{5}\epsilon^5+,\ \&\text{c.}\right),$$

and multiplying as before,

$$Q=2\pi b\left(\frac{2}{3}-\frac{2}{15}\epsilon^2\right)=\frac{4\pi b}{3}\left(1-\frac{1}{5}\epsilon^2\right).$$

Now, if instead of ϵ we introduce the ellipticity e, and make $e=\frac{b-a}{a}$, we shall have $b=a\,(1+e)$. But we have already assumed $b^2=a^2\,(1+\epsilon^2)$; whence $1+e=\sqrt{1+\epsilon^2}$: and on rejecting the second and all the higher powers of e (which may be done because e is supposed to be a very small fraction), we have $1+2e=1+\epsilon^2$, and consequently $2e=\epsilon^2$. Substituting this in the above formulas, and observing that $b=a\,(1+e)$, we get

$$P=\frac{4\pi a}{3}\left(1+\frac{4}{5}e\right);\quad Q=\frac{4\pi a}{3}\left(1+\frac{3}{5}e\right);$$

and since $\varphi=4\pi bm=4\pi a\,(1+e)\,m=4\pi am$ (for m and e being both very small fractions, their product me may be neglected), we have also

$$Q'=Q-\varphi=\frac{4\pi a}{3}\left(1+\frac{3}{5}e-3m\right).$$

Substituting these values of P and Q' in the equation of equilibrium, $Pa=Q'b=Q'a\,(1+e)$, there results

$$1+\frac{4}{5}e=(1+e)\left(1+\frac{3}{5}e-3m\right);$$

whence, rejecting terms multiplied by e^2 and em, we find

$$e=\frac{15}{4}m.$$

The ratio of the centrifugal force to gravitation at the equator is $\frac{\varphi}{Q'}$, or $\frac{3m}{1+\frac{3}{5}e-3m}=3m$; hence $e=\frac{5}{4}\cdot\frac{\varphi}{Q'}$; that is to say, the ellipticity of a homogeneous spheroid revolving about an axis, and whose form does not differ greatly from that of a sphere, is equal to the fraction formed by dividing five times the centrifugal force at the equator by four times the gravitation at the equator. By comparing the length of the arc described by a point on the earth's surface in a second of time, with the descent of falling bodies, Newton found this ratio in the case of the earth to be $\frac{1}{289}$, whence $m=\frac{1}{3\times289}=\frac{1}{867}$, and consequently $e=\frac{15}{4}\times\frac{1}{3\times289}=\frac{1}{231}$, so that, supposing the earth to be homogeneous, the ratio of its polar to its equatorial axis ought to be 230 to 231 very nearly.

Figure of the Earth.

The ellipticity deduced from the actual measurements of degrees, as well as from the variations of gravity indicated by pendulum observations, is considerably less than $\frac{1}{231}$; consequently the earth is not homogeneous.

In what precedes, we have supposed generally $m = \frac{\pi}{t^2}$, and found for the limit which m cannot exceed, $m = 0{\cdot}11234$. Let m' be what m becomes in the case of the earth, and t' be the time (expressed in parts of a mean solar day) in which the earth makes one revolution about its axis; t being the time in which a spheroid of the same mean density as the earth would make a revolution when $m = 0{\cdot}11234$. We have then $m' = \frac{\pi}{t'^2}$, whence $m' : m = t^2 : t'^2$, whence $t = t'\sqrt{\frac{m'}{m}}$. But $t' = 23$ h. 56 m. 4 sec. $= {\cdot}99727$ day; and we have already found $m' = \frac{1}{867}$; therefore $t = {\cdot}99727\sqrt{\frac{1}{867 \times 0{\cdot}11234}} = 0{\cdot}1009$ day $= 2$ hours 25 minutes 26 seconds. Hence a fluid mass of the same density as the earth could not be in equilibrium with the figure of an ellipsoid of revolution if its time of rotation were less than 2 h. 25 m. 26 sec. If the time of rotation is greater, there are two elliptic spheroids, and not more, which, with the same velocity of rotation, give a figure of equilibrium.

Hitherto we have considered only one of the roots of equation (1), and seen that it gives 230 : 231 as the ratio of the polar to the equatorial axis. Let us now inquire into the value of the other root.

As the value of ε^2 in the former case was very small, it will now be large; we may therefore proceed as follows: The identical equation

$$\text{arc tan. } \varepsilon = \frac{1}{2}\pi - \text{arc tan.} \frac{1}{\varepsilon}$$

gives

$$\text{arc tan. } \varepsilon = \frac{1}{2}\pi - \frac{1}{\varepsilon} + \frac{1}{3\varepsilon^2} - \frac{1}{5\varepsilon^5} +, \text{ \&c.}$$

whence equation (1) becomes

$$\frac{3\varepsilon + 2m\varepsilon^3}{3\,\varepsilon^2} = \frac{1}{2}\pi - \frac{1}{\varepsilon} + \frac{1}{3\varepsilon^2} - \frac{1}{5\varepsilon^5} +, \text{ \&c.}$$

Reverting this series, in order to find ε in a series proceeding by the powers of m, we get

$$\varepsilon = \frac{\pi}{4m} - \frac{8}{\pi} + \frac{12m}{\pi}\left(1 - \frac{64}{3\pi^2}\right) +, \text{ \&c.}$$

or

$$\varepsilon = {\cdot}785398\,\frac{1}{m} - 2{\cdot}546479 - 4{\cdot}436656\,m.$$

Relatively to the earth, it has been seen that $m = \frac{1}{867}$; by substituting which in the above equation, we find $\varepsilon = 680$ nearly; so that $\sqrt{1+\varepsilon^2}$, the ratio of the equatorial to the polar axis, is 680 : 1. In this case the spheroid is extremely flattened.

In the preceding propositions it has been demonstrated that a fluid mass of uniform density revolving about a fixed axis will be *in equilibrio*, if its form is that of an oblate spheroid, provided the velocity of rotation does not exceed a certain limit, which has been ascertained. But it has been remarked, that if the same relation exists between the attraction and the centrifugal force as exists in the case of the earth, the ellipticity of such a spheroid would be different from the actual ellipticity of the earth, as determined by observation. It follows that the terrestrial spheroid must be heterogeneous, or of variable density; and this supposition is rendered more probable by what is otherwise known of the nature of the earth. The difficulties of the problem are however greatly increased in the case of a heterogeneous fluid; indeed it is only brought within the power of analysis by assuming that the form of the revolving mass differs very little from that of a sphere, and that it is regularly composed of concentric layers, increasing in density from the surface towards the centre, according to a determinate law. Admitting these assumptions, it may be demonstrated that the oblate spheroid of revolution is in this case also a figure of equilibrium.

The demonstration will be greatly simplified by means of the two following propositions respecting the attraction of homogeneous spheroids of small ellipticity, and which are easily deduced from the properties demonstrated in the article ATTRACTION.

PROP. V.—To find the measure of the attractive forces that urge a particle situated any where within or in the surface of a homogeneous oblate spheroid of revolution, in the directions parallel and perpendicular to the axis, the ellipticity being small.

Let D be the particle, x and y its rectangular co-ordinates (x being taken along the axis, and y perpendicular to the axis, in the meridional plane passing through D); let also X and Y denote the attractive forces soliciting the particle in those directions, and $k =$ the density of the spheroid.

By ATTRACTION (25), $P : X = a : x$, and $Q : Y = b : y$; therefore $X = P\frac{x}{a}$ and $Y = Q\frac{y}{b}$. But it has been already shown, that when the elipticity is small,

$$P = \frac{4\pi}{3}a\left(1 + \frac{4}{5}e\right),\; Q = \frac{4\pi}{3}a\left(1 + \frac{3}{5}e\right),$$

therefore

$$X = \frac{4\pi}{3}x\left(1 + \frac{4}{5}e\right);\; Y = \frac{4\pi}{3}\frac{a}{b}y\left(1 + \frac{3}{5}e\right).$$

Introducing the density k, to which the attraction is directly proportional, and observing that $\frac{a}{b} = \frac{1}{1+e}$, these expressions become

$$X = \frac{4\pi}{3}kx\left(1 + \frac{4}{5}e\right);\; Y = \frac{4\pi}{3}ky\left(1 - \frac{2}{5}e\right).$$

PROP. VI.—To find the measure of the forces with which an oblate spheroid, whose ellipticity is small, attracts a particle situated any where without it, in the direction parallel to the axis, and in the direction perpendicular to the axis, the density being uniform.

Let PQ (fig. 14) be the given spheroid, of which the axes are a and b, D the given point without the spheroid, and x' y' the co-ordinates of D. From the two assumed equations $b'^2 - a'^2 = b^2 - a^2$, and $\frac{x'^2}{a'^2} + \frac{y'^2}{b'^2} = 1$, find a' and b', and conceive another spheroid P′Q′ to be described whose polar and equatorial semidiameters are respectively a' and b', whose centre coincides with that of the given spheroid, and which has its equator in the same plane. The surface of this spheroid, in consequence of the equation $\frac{x'^2}{a'^2} + \frac{y'^2}{b'^2} = 1$, will necessarily pass through the point D. Make $x = \frac{ax'}{a'}$, $y = \frac{by'}{b'}$; then, by what is demonstrat-

ed in ATTRACTION (26), the point D′, whose co-ordinates are x and y, is in the surface of the given spheroid PQ; and the attraction of the spheroid PQ on a particle at D is to the attraction of the spheroid P′Q′ on the point D′, as $b^2 : b'^2$ in the direction perpendicular to the equator, and as $ab : a'b'$ in the direction perpendicular to a plane passing through the axis. If, therefore, we denote by X and Y the attractions of the given spheroid PQ on D, and by X′ and Y′ those of the spheroid P′Q′ on D′, in the directions of the co-ordinates x and y respectively, we shall have

$$X : X' = b^2 : b'^2, \text{ and } Y : Y' = ab : a'b',$$

consequently

$$X = \frac{b^2}{b'^2} X', \; Y = \frac{ab}{a'b'} Y'.$$

But by the last proposition,

$$X' = \frac{4\pi}{3} kx \left(1 + \frac{4}{5} e'\right), \; Y' = \frac{4\pi}{3} ky \left(1 - \frac{2}{5} e'\right)$$

(e' being the ellipticity of the spheroid P′Q′p'); therefore

$$X = \frac{4\pi}{3} \frac{b^2}{b'^2} k \left(1 + \frac{4}{5} e'\right) x, \; Y = \frac{4\pi}{3} \frac{ab}{a'b'} k \left(1 - \frac{2}{5} e'\right) y;$$

and, on substituting for x and y their values $\frac{a}{a'} x'$ and $\frac{b}{b'} y'$, we have

$$X = \frac{4\pi}{3} \frac{ab^2}{a'b'^2} k \left(1 + \frac{4}{5} e\right) x'; \; Y = \frac{4\pi}{3} \frac{ab^2}{a'b'^2} k \left(1 - \frac{2}{5} e\right) y'.$$

We must now eliminate from these equations the quantities a', b', and e', by means of the three equations of condition $\frac{x'^2}{a'^2} + \frac{y'^2}{b'^2} = 1$, $b'^2 - a'^2 = b^2 - a^2$, and $b' = a'(1 + e')$. In order to abridge, let r = CD, the distance of D from the centre of the spheroid, and θ = the angle DCP. We have then $x = r \cos. \theta$, $y = r \sin. \theta$, and the first of the above equations becomes $r^2 (b'^2 \cos.^2 \theta + a'^2 \sin.^2 \theta) = a'^2, b'^2$, which, since $b' = a'(1 + e')$, and consequently $b'^2 = a'^2 (1 + 2e')$, reduces to $r^2 (1 + 2e' \cos.^2 \theta) = a'^2 (1 + 2e')$. On dividing by $1 + 2e'$, and neglecting terms multiplied by e^2, this gives $a'^2 = r^2 (1 - 2e' \sin.^2 \theta)$, and consequently $a'^2 e' = r^2 e'$.

But $b'^2 = a'^2 (1 + 2e')$, therefore $b'^2 - a'^2 = 2a'^2 e'$; and in like manner, $b^2 - a^2 = 2a^2 e$; whence, by reason of $b'^2 - a'^2 = b^2 - a^2$, we have $a'^2 e' = a^2 e$; consequently $a^2 e = r^2 e'$, and $e' = \frac{a^2}{r^2} e$. Substituting this value of e' in the equation $a'^2 = r^2 (1 - 2e' \sin.^2 \theta)$, we get $a'^2 = r^2 - 2a^2 e \sin.^2 \theta$; whence, neglecting terms in e^2, $a' = r - \frac{a^2 e \sin.^2 \theta}{r}$. From the equation $a'^2 = r^2 (1 - 2e' \sin.^2 \theta)$ we also get $b'^2 - a'^2 = b'^2 - r^2 (1 - 2e' \sin.^2 \theta)$; but $b'^2 - a'^2 = 2a'^2 e' = 2a^2 e$; therefore $2a^2 e = b'^2 - r^2 (1 - 2e' \sin.^2 \theta)$, and consequently $b'^2 = r^2 + 2a^2 e \cos.^2 \theta$.

From these values of a' and b'^2 we find, on multiplying and neglecting terms involving the square and higher powers of e, $a' b'^2 = r^3 + 2a^2 re \cos.^2 \theta - a^2 re \sin.^2 \theta = r^3 + ra^2 e (2 - 3 \sin.^2 \theta)$. But $b^2 = a^2 (1 + 2e)$, and $ab^2 = a^3 (1 + 2e)$, therefore

$$\frac{ab^2}{a'b'^2} \left(1 + \frac{4}{5} e'\right) = \frac{ab^2}{a'b'^2} \left(1 + \frac{4a^2}{5r^2} e\right)$$
$$= \frac{a^3}{r^3} \left\{1 + 2e - e \frac{3a^2}{5r^2} (2 - 5 \sin.^2 \theta)\right\},$$

and

$$\frac{ab^2}{a'b'^2} \left(1 - \frac{2}{5} e'\right) = \frac{ab^2}{a'b'^2} \left(1 - \frac{2a^2}{5r^2} e\right)$$
$$= \frac{a^3}{r^3} \left\{1 + 2e - e \frac{3a^2}{5r^2} (4 - 5 \sin.^2 \theta)\right\}.$$

Substituting these expressions in the above values of X and Y, writing $r \cos. \theta$ for x', and $r \sin. \theta$ for y', we get

$$X = \frac{4\pi}{3} k \frac{a^3}{r^2} \left\{1 + 2e - e \frac{3a^2}{5r^2} (2 - 5 \sin.^2 \theta)\right\} \cos. \theta,$$

$$Y = \frac{4\pi}{3} k \frac{a^3}{r^2} \left\{1 + 2e - e \frac{3a^2}{5r^2} (4 - 5 \sin.^2 \theta)\right\} \sin. \theta.$$

Thus the expression of the force with which a homogeneous spheroid attracts a point placed without it has been found in finite terms. The ingenious process of analysis by which this result, of very great importance in the theory of the figures of the planets, has been obtained, is one of the many discoveries for which mathematical science is indebted to Mr Ivory.

PROP. VII.—To find the measure of the forces with which an oblate spheroid whose ellipticity is small, attracts a particle situated any where on its surface, in the direction parallel to the axis, and in the direction perpendicular to the axis, the density being variable.

In the solution of this problem we suppose the spheroid to be composed of infinitely thin concentric layers, bounded by spheroidal surfaces of different ellipticities, and that the density is uniform for a single layer, but variable from one layer to another.

Let P′Q′ (fig. 15) be the given spheroid, a', b' its polar and equatorial radii, and D the attracted point. Let D′ be any point within the spheroid P′Q′, and PQD′ be a spheroidal surface at every point of which the density is the same, a, b its polar and equatorial radii, and e its ellipticity. Also let p, q be another spheroidal surface indefinitely near PQ, of which the polar radius C$p = a + da$, the equatorial C$q = b + db$, and the ellipticity $= e + de$. Between the two surfaces PQ and pq the density k may be supposed constant.

In order to find the attraction of the whole spheroid on D, we must first find expressions in terms of a for the forces with which D is attracted by the elementary layer PQpq; the integration of these expressions from $a = 0$ to $a = a'$ will give the attractions of the spheroid.

Conceive for a moment the density of the spheroid CPQ to be uniform and $= k$. The forces X and Y with which this spheroid attracts D are given by the last proposition, and the forces with which Cpq attracts D will be found by substituting $a + da$ for a, and $e + de$ for e in the same expressions for X and Y. Now, as the ellipticity varies from C to P′, e may be regarded as a function of a; its variation is consequently included in the variation of a, and the attractions of the spheroid Cpq hence become

$$X + \frac{dX}{da} da, \; Y + \frac{dY}{da} da.$$

The difference between the attractions of the spheroids Cpq and CPQ is the attraction of the layer PQqp, which is therefore $\frac{dX}{da} da$, and $\frac{dY}{da} da$. Hence, if we represent the attractions of the whole heterogeneous spheroid CP′Q′ by X′ and Y′, we shall have

$$X' = \int \frac{dX}{da} da, \; Y' = \int \frac{dY}{da} da,$$

which integrals must be taken from $a = 0$ to $a = a'$, the density k, which enters as a factor into X and Y, being regarded as a function of a.

Let us first consider the force X′. By last proposition we have

$$X = \frac{4\pi}{3} k \frac{a^3}{r^2} \left\{1 + 2e - e \frac{3a^2}{5r^2} (2 - 5 \sin.^2 \theta)\right\} \cos. \theta,$$

whence

$$\frac{dX}{da}da=\frac{4\pi k}{3\,r^2}\left\{d(\overline{1+2e}.a^3)-\frac{3}{5r^2}(2-5\sin.^2\theta)d(a^5e)\right\}\cos.\theta.$$

Integrating, and regarding k as variable, and a function of a, and going through the same process with respect to Y, we get for the attractions of the spheroid CP′Q′ in the directions respectively parallel and perpendicular to the axis,

$$X'=\frac{4\pi}{3}\left\{\frac{1}{r^2}\int kd(\overline{1+2e}.a^3)-\frac{3(2-5\sin.^2\theta)}{5r^4}\int kd(a^5e)\right\}\cos.\theta,$$

$$Y'=\frac{4\pi}{3}\left\{\frac{1}{r^2}\int kd(\overline{1+2e}.a^3)-\frac{3(4-5\sin.^2\theta)}{5r^4}\int kd(a^5e)\right\}\sin.\theta.$$

Prop. VIII.—To find the measure of the forces with which a heterogeneous layer, included between two level surfaces, attracts a particle situated anywhere within it.

Let D′ (fig. 15) be the given particle situated within the spheroidal layer PQQ′P′, x' and y' the co-ordinates of D′, a = polar semiaxis, and e = eccentricity of the inner surface PQ passing through D′, a' = polar semiaxis of the exterior surface P′Q′, and k = density at the interior surface.

Suppose the interior of the spheroid PQ to be filled with matter of uniform density k, then by Proposition V., the attractions of that spheroid on D′ are

$$X=\frac{4\pi}{3}k\left(1+\frac{4}{5}e\right)x',\ Y=\frac{4\pi}{3}k\left(1-\frac{2}{5}e\right)y';$$

or, changing x' into r cos. θ, and y' into r sin. θ,

$$X=\frac{4\pi}{3}r'k\left(1+\frac{4}{5}e\right)\cos.\theta,\ Y=\frac{4\pi}{3}rk\left(1-\frac{2}{5}e\right)\sin.\theta.$$

Now the attraction of another similar spheroid Cpq, whose polar semiaxis is $a+da$, will be found by substituting $a+da$ for a and $e+de$ for e in the above expressions; and the attraction of the elementary layer PQpq on D will be the difference of these attractions. But

$$\frac{dX}{da}da=\frac{4\pi}{3}\cdot\frac{4}{5}rkde\cos.\theta,$$

$$\frac{dY}{da}da=-\frac{4\pi}{3}\cdot\frac{2}{5}rkde\sin.\theta,$$

e being regarded as a function of a. The integral of these expressions will give the attraction of the layer PQqp on D′; but as this attraction diminishes while a increases, if we take A to represent what $\int kde$ becomes when a becomes a', and denote by X″ and Y″ the attractions of the whole layer PQQ′P′, we shall have

$$X''=\frac{4\pi}{3}\cdot\frac{4}{5}r\left(A-\int kde\right)\cos.\theta,$$

$$Y''=-\frac{4\pi}{3}\cdot\frac{2}{5}r\left(A-\int kde\right)\sin.\theta.$$

Prop. IX.—To find the attraction of a heterogeneous spheroid on a point within it.

Let D′ (fig. 14) be the given point, and CP′Q′ the given spheroid, r cos. θ and r sin. θ the co-ordinates of D′, a', and e', the polar semiaxis and ellipticity of the given spheroid CP′Q′, and a and e those of the spheroidal surface passing through D′ and all the points of equal density.

The whole force urging D′ may be conceived as made up of two parts; that arising from the spheroid CPQ, the surface of which passes through D, and that of the spheroidal shell PQQ′P′. The first of these forces is given by the expressions represented by X′ and Y′ in Prop. VII. and the second by the expressions represented by X″ and Y″ in Prop. VIII. Therefore, if we denote by X‴ and Y‴ the attractions of the whole spheroid on the particle D′, in the direction parallel to the axis, and in the direction perpendicular to the axis, we shall have

$$X'''=X'+X'',\quad Y'''=Y'+Y'';$$

and if the spheroid revolves about its polar axis, Y‴ must be diminished by the amount of the centrifugal force $=\frac{4\pi}{3}\cdot\frac{3\pi}{t^2}r\sin.\theta$; therefore the attractions of the given spheroid on the point D′ are

$$X'''=X'+X'',$$

$$Y'''=Y'+Y''-\frac{4\pi}{3}\cdot\frac{3\pi}{t^2}r\sin.\theta.$$

Prop. X.—To find the ratio of the ellipticity to the density of any level surface, when the component of all the forces urging any point on the surface is perpendicular to the surface.

The forces urging the particle D′ (fig. 14) being X‴ and Y‴, in order that their resultant may be perpendicular to the surface, we must have

$$X''':Y'''=\text{ME}:\text{ED (fig. 10)}.$$

But ME (the subnormal)$=\frac{b^2}{a^2}x'=(1+2e)x'$, and ED$=y'$; therefore $X''':Y'''=(1+2e)x':y'$, whence, substituting r cos. θ for x' and r sin. θ for y', $\frac{X'''}{\cos.\theta}-\frac{Y'''}{\sin.\theta}(1+2e)=0$.

Now, if we substitute for X‴ in this equation the values of X′ and X″ given by Propositions VII. and VIII., and for Y‴ the values of Y′ and Y″ multiplied by $(1+2e)$, and neglect terms involving e^2, we shall find, on changing the signs and having regard to the centrifugal force,

$$\frac{2e}{r^2}\int kd(\overline{1+2e}.a^3)-\frac{6}{5r^4}\int kd(a^5e)-\frac{6}{5}r\left(A-\int kde\right)-\frac{3\pi r}{t^2}=0.$$

Dividing by $2r$, and substituting a for r (which may be done without sensible error, because all the terms of the equation are small, and because r^2 differs from a^2 only by a quantity depending on the ellipticity e), we shall find

$$\frac{e}{a^3}\int kd(\overline{1+2e}.a^3)-\frac{3}{5a^5}\int kd(a^5e)-\frac{3}{5}\left(A-\int kde\right)-\frac{3\pi}{2t^2}=0.$$

From this we infer that if k and e have the relation to each other indicated by this equation, and that e is very small from $a=0$ to $a=a'$, each of the level surfaces will be intersected at every point by the resultant of the attractive forces under an angle which will differ from a right angle only by an infinitesimal of the second order, supposing the centrifugal force to be very small in comparison of gravity. Hence, neglecting quantities of the second order, the elliptical spheroid (supposing the equation possible) is a figure of equilibrium.

In order to discover whether the equation which has now been obtained is possible, it must be differentiated twice in order to eliminate $\int kd(a^5e)$ and $\int kde$, both of which contain the ellipticity e. Observing that as the first term is multiplied by e, we may suppose, without sensible error, $\frac{e}{a^3}\int kd(\overline{1+2e}.a^3)=\frac{e}{a^3}\int kd(a^3)=\frac{3e}{a^3}\int ka^2da$, and the first differentiation gives, on multiplying by a^6,

$$\frac{de}{da}a^3\int ka^2da-3a^2e\int ka^2da+\int kd(a^5e)=0.$$

Differentiating again, and considering da as constant, we shall find, after reduction,

$$\frac{d^2e}{da^2}+\frac{2ka^2}{\int ka^2da}\cdot\frac{de}{da}+\left(\frac{2ka}{\int ka^2da}-\frac{6}{a^2}\right)e=0.$$

This is the equation given by Clairaut (*Figure de la Terre*, p. 276). It can be integrated by the usual methods when k is expressed in terms of a; consequently the equilibrium is always possible if the density is a function of the distance from the centre. The integration being performed, an equation will result between the densities and ellipticities of the different spheroidal layers, by means of which, when one of these elements is supposed to be given, the other can be determined.

PROP. XI.—To find the whole force urging a particle situated at any point on the surface of a heterogeneous spheroid revolving about its shorter axis.

By Prop. VII. the force urging the particle in the direction of the axis is X', and in the direction perpendicular to the axis Y'; but in consequence of the centrifugal force, the latter becomes $Y'-\varphi$, therefore the whole force urging D in the direction of the normal

$$=\sqrt{X'^2+(Y'-\varphi)^2}.$$

Neglecting the terms which involve e^2 and $e\varphi$ (φ being small as well as e), and putting $\int kd(\overline{1+2e}\cdot a^3)=M$, and $\int kd(a^5 e)=N$, and substituting $\frac{4\pi^2}{t^2}r\sin.\theta$ for φ, we get

$$X'^2=\left(\frac{4\pi}{3r^2}\right)^2\left\{M^2\cos.^2\theta-\frac{6(2-5\sin.^2\theta)}{5r^2}MN\cos.^2\theta\right\},$$

$$(Y'-\varphi)^2=\left(\frac{4\pi}{3r^2}\right)^2\left\{M^2\sin.^2\theta-\frac{6(4-5\sin.^2\theta)}{5r^2}MN\sin.^2\theta-\frac{6M\pi r^3\sin.^2\theta}{t^2}\right\};$$

whence, putting $X^2+(Y-\varphi)^2=U^2$, there results

$$U^2=\left(\frac{4\pi}{3r^2}\right)^2\left\{M^2-\frac{6(2-3\sin.^2\theta)}{5r^2}MN-\frac{6M\pi r^3\sin.^2\theta}{t^2}\right\},$$

and extracting the square root,

$$U=\frac{4\pi}{3}\left\{\frac{M}{r^2}-\frac{3(2-3\sin.^2\theta)}{5r^4}N-\frac{3\pi r\sin.^2\theta}{t^2}\right\}.$$

But the equation of the ellipse gives

$$r^2\cos.^2\theta+\frac{r^2\sin.^2\theta}{1+2e}=a^2;$$

whence we deduce $r^2=a^2(1+2e\sin.^2\theta)$; therefore, substituting and dividing, and neglecting terms in Ne and $e\varphi$,

$$U=\frac{4\pi}{3}\left\{\frac{M}{a^2}(1-2e\sin.^2\theta)-\frac{3}{5}\cdot\frac{(2-3)\sin.^2\theta}{a^4}N-\frac{3\pi^2 a\sin.^2\theta}{t^2}\right\}.$$

Let the centrifugal force at the equator $=m\times$ gravity; then, if m is a very small fraction (as in the case of the earth, where $m=\frac{1}{289}$), terms involving the product me may be neglected, and the last equation, multiplied by m, will become

$$mU=\frac{4\pi}{3}\cdot\frac{M}{a^2}m;$$

but the centrifugal force at the equator $=\frac{4\pi^2}{t^2}a(1+e)$, which does not differ sensibly from $\frac{4\pi^2}{t^2}a$; therefore $\frac{4\pi^2}{t^2}a=\frac{4\pi}{3}\frac{M}{a^2}m$, or $\frac{3\pi}{t^2}=\frac{Mm}{a^3}$. Now, at the surface the equation of equilibrium in Prop. X. becomes

$$\frac{e}{a^3}M-\frac{3}{5a^5}N-\frac{3\pi}{2t^2}=0$$

therefore

$$\frac{e}{a^3}M-\frac{3}{5a^5}N-\frac{Mm}{2a^3}=0,$$

whence

$$\frac{3N}{5a^4}=\frac{M}{a^2}\left(e-\frac{m}{2}\right).$$

Substituting these values of $\frac{3\pi}{t^2}$ and $\frac{3N}{5a^4}$ in the above value of U, we get, after reduction,

$$U=\frac{4\pi}{3}\cdot\frac{M}{a^2}\left\{1-2e+m-\left(\frac{5}{2}m-e\right)\sin.^2\theta\right\}.$$

At the equator $\sin.\theta=1$, and this equation becomes

$$Q=\frac{4\pi}{3}\cdot\frac{M}{a^2}\left\{1-e-\frac{3}{2}m\right\};$$

and at the pole, where $\sin.\theta=0$, it gives

$$P=\frac{4\pi}{3}\cdot\frac{M}{a^2}\left\{1-2e+m\right\};$$

consequently the difference between the force of gravity at the pole and that of gravitation at the equator is $\frac{4\pi}{3}\cdot\frac{M}{a^2}\left(\frac{5m}{2}-e\right)$. Dividing this by the polar gravity P, we get for the quotient $\frac{5m}{2}-e$, which, therefore, expresses the ratio of the excess of the polar gravity above the gravitation at the equator to the gravity at the pole. Let this ratio $=n$, we have then

$$n=\frac{5}{2}m-e;$$

a very remarkable relation between the gravity and ellipticity, which was discovered by Clairaut, and is generally called *Clairaut's theorem.*

If we substitute $1-\cos.^2\theta$ for $\sin.^2\theta$ in the equation

$$U=\frac{4\pi}{3}\cdot\frac{M}{a^2}\left\{1-2e+m-\left(\frac{5}{2}m-e\right)\sin.^2\theta\right\},$$

we get

$$U=\frac{4\pi}{3}\cdot\frac{M}{a^2}\left\{1-e-\frac{3}{2}m+\left(\frac{5}{2}m-e\right)\cos.^2\theta\right\};$$

or, neglecting quantities of the order me,

$$U=\frac{4\pi}{3}\cdot\frac{M}{a^2}\left(1-e-\frac{3}{2}m\right)\left\{1+\left(\frac{5}{2}m-e\right)\cos.^2\theta\right\};$$

whence we have $U=Q(1+n\cos.^2\theta)$. Now in this equation the angle θ may be taken for the complement of the latitude, from which indeed it differs only by a quantity of the second order, and the equation then becomes $U=Q(1+n\sin.^2 l)$; whence we infer that, on going from the equator towards the pole, the increase of gravity is proportional to the square of the sine of the latitude.

Let p be the length of the seconds pendulum at the equator, p' its length at any latitude l, and U the intensity of the gravitating force at the same latitude l. When the time of oscillation is constant, the length of the pendulum is directly proportional to the intensity of gravity; therefore $p':p=U:Q$, and consequently

$$\frac{p'-p}{p}=\frac{U-Q}{Q}.\quad\text{But } U=Q(1+n\sin.^2 l),$$

therefore, $\frac{p'-p}{p}=n\sin.^2 l=\left(\frac{5m}{2}-e\right)\sin.^2 l.$

At the pole $\sin.l=1$, and $\frac{p'-p}{p}=\frac{5m}{2}-e$; therefore, since $e=\frac{b-a}{a}$, $\frac{p'-p}{p}+\frac{b-a}{a}=\frac{5m}{2}.$

Now it has been shown that in the case of a homogeneous spheroid the ellipticity is $\frac{5\,m}{4}$; hence we have this theorem:

In the case of a heterogeneous spheroid, the excess of the length of the pendulum at the pole above its length at the equator divided by its length at the equator, and the excess of the axis of the equator above the polar axis divided by the polar axis, form two fractions, of which the sum is constant, and equal to twice the ellipticity the spheroid would have if homogeneous.

SECTION IV.

ON THE FIGURE OF THE EARTH AS DETERMINED BY OBSERVATIONS OF THE PENDULUM.

As the various methods of determining the length of a pendulum which makes a given number of vibrations in a mean solar day, and the corrections that are required to reduce the observations to the same circumstances in respect of altitude, temperature, barometric pressure, &c. form the subject of a separate article, we shall here limit ourselves to a brief abstract of the results of some of the latest and best observations.

The ellipticity of the earth is deduced from the observed number of vibrations made by an invariable pendulum of a given length at different latitudes, by means of the theorem of Clairaut. Let $N =$ the number of oscillations made by a pendulum at the equator in a mean solar day, $N' =$ the number of oscillations made by the same pendulum at the latitude l; then Q representing, as before, the gravitation at the equator, and U the gravitation at latitude l, we have, by the last proposition in the preceding section,

$$U = Q\,(1 + n \sin.^2 l).$$

But by the property of the invariable pendulum, the square of the number of vibrations is directly proportioned to the force of gravitation; therefore $U : Q = N'^2 : N^2$, whence $N'^2 = N^2\,(1 + n \sin.^2 l)$.

In this equation $n = \frac{5}{2}\,m - e = \frac{5}{2 \times 289} - e$; therefore, as N'^2 is given by observation at any station, we can, by combining the results at two different latitudes, determine N and n, and consequently e. The pendulum gives no information respecting the magnitude of the earth.

Instead of N and N′, we might substitute in the above equation the lengths of the seconds pendulum at the equator, and the latitude l (the length of the seconds pendulum being also directly proportional to the intensity of gravity); but as the invariable pendulum is now almost universally employed for the measurement of the variations of gravity, the formula under the above form is more immediately applicable to the results of observation. The absolute length of the pendulum (which is not very easily determined) has no concern with the present question.

For the purpose of exhibiting the variations of gravity, we shall confine our attention to the results that have been found from observations with the invariable pendulum. The results given by pendulums of a different kind are probably not less exact, but they are not directly comparable, on account of the great uncertainty that remains respecting the correction that ought to be applied for the buoyancy of the atmosphere.

In the seventh volume of the *Memoirs of the Royal Astronomical Society*, Mr Baily has given the results of fourteen different sets of observations with invariable pendulums. They are as follows:

1. The observations of Captain Kater at different stations in Great Britain. These are detailed in the *Philosophical Transactions* for the year 1819.

2. Those of Mr Goldingham at London and Madras, and of Mr Lawrence and Mr Robinson with the same pendulum at the small island of Pulo Guansah Lout, on the western coast of Sumatra, and almost immediately under the equator. (*Phil. Trans.* 1822.)

3. Those of Captain Hall at the Galapagos Islands, San Blas, Rio Janeiro, and London. (*Phil. Trans.* 1823.)

4. Those of Sir Thomas Brisbane at London and Paramatta. (*Phil. Trans.* 1823.)

5. Those of Captain Sabine in various parts of the Atlantic Ocean and the North Sea, in the years 1822–4. (Sabine's *Account of Experiments*, &c. 1825.)

6. Those of Captain Foster at Greenwich, London, and Port Bowen. (*Phil. Trans.* 1826.)

7. Those of Mr Fallows at the Cape of Good Hope. The same pendulum was swung in London previous to its departure.

8, 9, 10. Those of Captain Sabine for the purpose of determining the difference in the number of oscillations at London and Paris (*Phil. Trans.* 1828), London and Greenwich (*Phil. Trans.* 1829), and at Greenwich, London, and Altona (*Ibid.* 1829 and 1830).

11. Those of Captain Freycinet, who commanded an expedition fitted out by the French government in 1817, for the purpose of making scientific observations in a voyage round the world. The stations at which the experiments were made were the island of Rawak (near the coast of Guinea), Guam (one of the Ladrones), the Isle of France, Mowi (one of the Sandwich Islands), Rio Janeiro, Port Jackson, Cape of Good Hope, Paris, and the Falkland Islands. (*Voyage autour du Monde, par M. Freycinet.*)

12. Those of Captain Duperrey, who commanded another French expedition. The stations were, island of Ascension, Isle of France, Port Jackson, Toulon, Paris, and the Falkland Islands. (*Connoissance des Tems* for 1830.)

13. Those of Captain Leutke, a Russian officer, under whose orders a ship of war was dispatched to the South Seas, for the purpose, among other things, of swinging the pendulum at various places. The stations at which experiments were made were Ualan (one of the Caroline Isles), Guam, St Helena, Bonin Island (off the south-east coast of Japan), Valparaiso, Greenwich, Petropaulouski, Sitka (off the north-west coast of America), and Petersburg. (Mr Baily's Report in the *Memoirs of the Royal Astronomical Society*, vol. vii.)

14. Those of Captain Foster, in his last voyage, which commenced in 1828, and which form perhaps the most valuable series of the whole. The observations were made at fourteen different stations, principally in the southern hemisphere, from the equator to the latitude of 63°. Captain Foster carried out with him four pendulums, two of brass, one of iron, and one of copper, and at seven of the stations all four were swung. The details are published at full length in the volume of the *Astronomical Society's Memoirs* to which we have already referred, with an excellent Report by Mr Baily.

The results of all these observations are contained in the following table, in which the observed number of vibrations at each station is corrected, for any deviation from the standard temperature of 62°, or from the true correction for the buoyancy of the atmosphere, and afterwards reduced to a comparison with Captain Foster's mean pendulum, assumed as making 86,400 vibrations in a mean solar day at London.

No.	Station.	Latitude.	Vibrations. Observed.	Vibrations. Computed.	Difference.	Observer.
1	Rawak	0° 1′ 34″ S.	86261·46	86264·86	— 3·40	Freycinet.
2	Pulo Guansah Lout	0 1 49 N.	86266·64	86264·86	+ 1·78	Goldingham.
3	St Thomas	0 24 41 —	86268·84	86264·87	+ 3·97	Sabine.
4	Galapagos	0 32 19 —	86264·56	86264·88	— 0·32	Hall.
5	Para	1 27 0 S.	86260·61	86265·00	— 4·39	Foster.
6	Maranham	2 31 35 —	86258·74	86265·30	— 6·56	Foster.
7	Ditto	2 31 43 —	86259·19	86265·30	— 6·11	Sabine.
8	Fernando de Noronha	3 49 59 —	86271·20	86265·86	+ 5·34	Foster.
9	Ualan	5 21 16 N.	86275·44	86266·78	+ 8·66	Leutke.
10	Ascension	7 55 23 S.	86272·26	86269·06	+ 3·20	Foster.
11	Ditto	7 55 48 —	86272·06	86269·08	+ 2·98	Duperrey.
12	Ditto	7 55 48 —	86272·56	86269·08	+ 3·48	Sabine.
13	Sierra Leone	8 29 28 N.	86267·54	86269·70	— 2·16	Sabine.
14	Porto Bello	9 32 30 —	86272·01	86270·96	+ 1·05	Foster.
15	Trinidad	10 38 55 —	86267·24	86272·42	— 5·18	Foster.
16	Ditto	10 38 56 —	86266·78	86272·42	— 5·64	Sabine.
17	Bahia	12 59 21 S.	86272·38	86276·07	— 3·69	Sabine.
18	Madras	13 4 9 N.	86272·36	86276·19	— 3·83	Goldingham.
19	Guam	13 26 21 —	86280·64	86276·84	+ 3·80	Leutke.
20	Ditto	13 27 51 —	86282·98	86276·90	+ 6·08	Freycinet.
21	St Helena	15 54 59 S.	86288·29	86281·54	+ 6·75	Leutke.
22	Ditto	15 56 7 —	86288·29	86281·54	+ 6·75	Foster.
23	Jamaica	17 56 7 N.	86284·66	86285·90	— 1·24	Sabine.
24	Isle of France	20 9 23 S.	86297·60	86291·20	+ 6·40	Duperrey.
25	Ditto	20 9 56 —	86298·08	86291·23	+ 6·85	Freycinet.
26	Mowi	20 52 7 N.	86297·52	86293·00	+ 4·52	Freycinet.
27	St Blas	21 32 24 —	86288·80	86294·77	— 5·97	Hall.
28	Rio Janeiro	22 55 13 S.	86293·48	86298·52	— 5·04	Freycinet.
29	Ditto	22 55 22 —	86294·90	86298·52	— 3·62	Hall.
30	Bonin Island	27 4 12 N.	86322·06	86310·81	+ 11·25	Leutke.
31	Valparaiso	33 2 30 S.	86328·16	86330·82	— 2·66	Leutke.
32	Paramatta	33 48 43 —	86331·48	86333·55	— 2·07	Brisbane.
33	Port Jackson	33 51 34 —	86334·06	86333·68	+ 0·38	Freycinet.
34	Ditto	33 51 40 —	86332·94	86333·68	— 0·74	Duperrey.
35	Cape of Good Hope	33 54 37 —	86331·33	86333·90	— 2·57	Foster.
36	Ditto	33 55 15 —	86331·58	86333·95	— 2·37	Freycinet.
37	Ditto	33 55 56 —	86332·56	86333·98	— 1·42	Fallows.
38	Monte Video	34 54 26 —	86334·36	86337·48	— 3·12	Foster.
39	New York	40 42 43 N.	86358·06	86359·22	— 1·16	Sabine.
40	Toulon	43 7 20 —	86367·16	86368·48	— 1·32	Duperrey.
41	Paris	48 50 14 —	86388·01	86390·54	— 2·53	Freycinet.
42	Ditto	48 50 14 —	86388·30	86390·54	— 2·24	Sabine.
43	Ditto	48 50 14 —	86388·56	89390·54	— 1·98	Duperrey.
44	Shanklin Farm	50 37 24 —	86396·40	86397·32	— 0·92	Kater.
45	Greenwich	51 28 40 —	86398·90	86400·58	— 1·68	Foster.
46	Ditto	51 28 40 —	86399·24	86400·58	— 1·34	Leutke.
47	Ditto	51 28 40 —	86399·46	86400·58	— 1·12	Foster.
48	Ditto	51 28 40 —	86400·67	86400·58	+ 0·09	Sabine.
49	Ditto	51 28 40 —	86400·72	86400·58	+ 0·14	Sabine.
50	London	51 31 8 —	86399·76	86400·74	— 0·98	Fallows.
51	Ditto	51 31 8 —	86399·90	86400·74	— 0·84	Foster.
52	Ditto	51 31 8 —	86399·72	86400·74	— 1·03	Sabine.
53	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Kater.
54	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Goldingham.
55	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Hall.
56	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Brisbane.
57	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Sabine.
58	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Sabine.
59	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Sabine.
60	Ditto	51 31 17 —	86400·00	86400·75	— 0·75	Foster.
61	Falkland Island	51 31 44 S.	86399·84	86400·78	— 0·94	Duperrey.
62	Ditto	51 35 18 —	86396·74	86400·99	— 4·25	Freycinet.
63	Arbury Hill	52 12 55 N.	86403·68	86403·35	+ 0·33	Kater.
64	Petropaulouski	53 0 53 —	86408·90	86406·34	+ 2·56	Leutke.
65	Clifton	53 27 43 —	86407·48	86407·99	— 0·51	Kater.
66	Altona	53 32 45 —	86408·98	86408·28	+ 0·70	Sabine.
67	Staten Island	54 46 23 S.	86415·22	86412·80	+ 2·42	Foster.
68	Cape Horn	55 51 20 —	86417·98	86416·72	+ 1·26	Foster.
69	Leith Fort	55 58 41 N.	86418·02	86417·16	+ 0·86	Kater.
70	Sitka	57 2 58 —	86420·54	86420·96	— 0·42	Leutke.
71	Portsoy	57 40 59 —	86424·70	86423·21	+ 1·49	Kater.
72	Petersburg	59 56 31 —	86432·20	86430·94	+ 1·26	Leutke.
73	Unst	60 45 28 —	86435·40	86433·64	+ 1·76	Kater.
74	South Shetland	62 56 11 S.	86444·52	86440·65	+ 3·87	Foster.
75	Drontheim	63 25 54 N.	86438·64	86442·20	— 3·56	Sabine.
76	Hammerfest	70 40 5 —	86461·14	86462·23	— 1·09	Sabine.
77	Fort Bowen	73 13 39 —	86470·48	86468·06	+ 2·42	Foster.
78	Greenland	74 32 19 —	86470·72	86470·75	— 0·03	Sabine.
79	Spitzbergen	79 49 58 —	86483·28	86479·58	+ 3·70	Sabine.

Taking the mean results of the observed vibrations given in col. 4 of the above table, and forming with each of them the equation of condition $N'^2 = N^2 (1 + n \sin.^2 l)$, seventy-nine equations are formed, from which, on deducing the values of N^2 and n by the method of least squares, Mr Baily obtained the following results:

$$N^2 = 7441625711$$
$$n = \cdot 00514491$$
$$e = \frac{1}{285\cdot 26}$$

By means of these values of N^2 and n, the number of vibrations made by a pendulum which beats seconds at London, at any latitude l, supposing the earth to be a regular spheroid, is given by the formula

$$N' = 86246\cdot 8 (1 + \cdot 00514491 \sin.^2 l)^{\frac{1}{2}};$$

and from this the results given in col. 5 of the table have been computed.

Although the differences between the observed and computed vibrations are in some instances considerable, the observations are on the whole well represented by supposing the ellipticity $= \frac{1}{285\cdot 26}$ To be satisfied of this, it will be sufficient to remark, that as the differences in the table present twenty-four alternations of sign, the curve which represents all the observations intersects the meridian having that ellipticity no less than twenty-four times along an arc of 152° (from Spitzbergen to South Shetland), or, on an average, once for every $6\frac{1}{4}$ degrees; and (with the exception of the island of Bonin) the deviations on the opposite sides are nearly equal.

If, instead of seeking an ellipticity by the *fusion* (if we may so speak) and agglomeration of all the observations by the method of least squares, we consider the results of the different voyagers separately, we shall find marked differences among them. Taken by themselves, Captain Sabine's observations give $e = \frac{1}{288\cdot 4}$; Captain Foster's, $e = \frac{1}{289\cdot 5}$; Duperrey's, $e = \frac{1}{266\cdot 4}$; Freycinet's, $e = \frac{1}{267\cdot 6}$; and Leutke's, $e = \frac{1}{267\cdot 7}$. The singular agreement of the results of the foreign voyagers with each other, and their difference from those of Captains Sabine and Foster, which also agree well with each other, have not been satisfactorily explained.

In one of the numbers of the *Annales des Sciences d'Observation* (tome i. No. 3), M. Saigey has computed the ellipticity from fifty-one different observations, combined by the method of least squares. Captain Foster's observations are of course not included in the table; but it contains those of Biot, made with a variable pendulum at different stations along the French and British arcs of meridian, and more recently in Italy and the Lipari Islands. The result gives $e = \frac{1}{286\cdot 5}$.

The differences between the observed and computed values are, in many instances at least, too great to be ascribed entirely to errors of observation. They must, therefore, be occasioned by real differences in the intensity of gravity, arising either from variations in the density of the materials which compose the exterior crust of the earth, or from local deviations of its form from that of the regular spheroid. On attending to the preceding table, it will be perceived that the differences are generally in excess where the station is on small islands, and especially if situated at a great distance from the main land. From this it may be inferred, that such islands are composed of denser materials than the general crust of the earth; but it is not improbable that part of this effect may be occasioned by a difference of the level of the surface of the ocean. On the shores of elevated continents, the direction of gravity is altered by the action of the high land; and the surface of the water, which is perpendicular to gravity, deviates from the regular curvature, and becomes elevated above the general level of the ocean. Hence the apparent elevation is less than the real elevation of the station, and the observed intensity of gravity is consequently less than it was calculated to be. How far the disturbing influence of this cause may affect the results, will be better understood when we shall be furnished with numerous pendulum observations, made in the interior of the large continents, and at a great distance from the sea.

All the pendulum experiments agree in giving a greater ellipticity to the earth than that which is deduced from the comparison of arcs of meridian. To what cause this discrepancy is to be assigned is by no means apparent. The geological character of the country in the immediate neighbourhood of the station probably exerts a considerable influence in accelerating or retarding the pendulum; but the experiments have now been made at so many points, that we might expect to find the effects of local irregularities almost entirely eliminated, and a much nearer agreement between the results of the two methods of investigation than actually exists. We can, however, have no difficulty in giving the preference to the results of the geodetic measures.

It was mentioned in the first section of this article that the ellipticity of the earth may be deduced from certain inequalities in the motions of the moon, to which it gives rise; but this part of the subject belongs to the theory of the lunar perturbations. The ellipticity so deduced is about $\frac{1}{300}$, which agrees well with that given by the meridional arcs; and the result has the advantage of being entirely independent of local disturbance.

One conclusion cannot fail to be drawn from the results of this enquiry. However irregular the surface of the earth may be in its details, its general form agrees so nearly with the figure of hydrostatic equilibrium, that the agreement cannot be regarded as fortuitous or accidental. The regular increase of gravity from the equator to the poles, indicated by the pendulum experiments, also proves that it is symmetrically constituted, or that the materials in its interior are disposed about the centre of gravity in regular elliptical strata, and arranged according to the order of density. The earth must therefore have taken its present form while its particles were at liberty to arrange themselves in obedience to the forces arising from their mutual attractions and from the rotation; in other words, it must have existed at some period of time in a state of fluidity. This inference, which so many geological facts tend to confirm, may be extended to all the other planets.

(T. G.)

FILAMENT. See FIBRE.

FILANGIERI, GAETANO, celebrated for his valuable works on political economy and legislation, was born at Naples on the 18th of August 1752. He was the third son of Cesar prince of Araniello, by Marianna Montalto, daughter of the Duke of Fragnito. Gaetano from his infancy was destined for the profession of arms; when he was seven years of age he was enrolled in one of the royal regiments, and commenced actual service at the age of fourteen. His education was at first neglected, from a misconception of his character, which was supposed to be averse to all literary or speculative pursuits. A lucky accident, however, not only removed this impression but showed that his former impatience of the modes of tuition then in use arose from the clearness and vigour of his judgment. It happened that his brother's preceptor had one day mistaken the solution of some geometrical problem. Gaetano immediately perceived the source of this error, which he demonstrated to the master. This incident, apparently trivial, determined his future destiny. Encouraged by his success, he quitted the military service, and determined to follow his natural taste for science and philosophy. So diligent was he in repairing the defects of his education, that at twenty years of age he had acquired a knowledge of Greek and Latin, of ancient and modern history, of the great principles both of civil and of public law, and was besides well initiated in mathematical science. Although his genius inclined him solely to the study of legislation and policy, he sacrificed his views to the wishes of his friends, and entered on the profession of the law, which was then the certain road both to honour and fortune. His eloquence and his extensive knowledge soon obtained him success; and about this period a circumstance happened which greatly conduced to his celebrity. Enormous abuses prevailed in the judicial proceedings at Naples, arising from the uncertainty of the law, which occasioned constant misconceptions, and almost always led to arbitrary judgments. By a wise ordinance of the king, passed in the year 1774 at the suggestion of the minister Tanucci, those abuses were reformed; the law was restored to its proper authority; its judgments were freed from the control of precedents; and the judges were ordained in every case to publish the grounds of their decisions. Although this reform was generally applauded, it excited the murmurs of the bar. Filangieri now became the advocate of the court, and published a defence of the royal decree, founded upon the most enlarged views of equity and reason. The extensive knowledge and matured judgment displayed in this performance attracted the attention of the ministers, and Filangieri was encourged to pursue the course in which he had already acquired so much distinction. Through the influence of his uncle, the Archbishop of Palermo, he was in 1777 placed in an honourable office at court; and almost at the same time he was named officer of the royal corps of marine volunteers, who were more particularly attached to the king's person. But his abode at court neither broke in upon his regular habits of life, nor interrupted the course of his studies; nor did he allow it to interfere with the composition of the great work on legislation and government in which he was engaged, and to which for several years he had devoted all his inquiries. About the commencement of the eighteenth century a great school of philosophy had been formed at Naples, in which the principles of the civil law, of the law of nations, and of legislation, were established on the solid and comprehensive basis of general utility. From this school numerous works of celebrity have proceeded; amongst others, the great work of Beccaria, which, though confined to one branch of legislation, contains principles which are of universal application. There was still wanting, however, a general treatise on legislation, for the purpose of examining the science in all its relations, and of laying down some common and universal principles of equity and expediency as its only true basis; and it was to this important undertaking that Filangieri's philosophical mind was now directed. His subject he proposed to divide into seven books. The first, in which he demonstrates the general rules of legislation, and the second, which treats on political laws, and on those laws also which are connected with the general structure of society, appeared at Naples in 1780; and such was its popularity, that not only in Italy, but throughout Europe at large, the author was ranked among the most celebrated writers on public law. According to his theory, the goodness of laws is either absolute or relative. It is absolute when they are agreeable to those great and universal principles of equity and expediency which are obligatory on man under every diversity of country, climate, government, or manners; it is relative, according as the laws agree with the nature of the government, with the genius and character of the people, with the climate, with the fertility or sterility of the soil, with the physical circumstances of the country, with the religion of the inhabitants, and with the degree of civilization to which they have advanced. In his second book, which treats of political laws, and of those laws also which are connected with the general economy of society, he examines two points; namely, the state of population and of wealth. With respect to the first point, the great question which he considers is, whether Europe is as populous as it might be? This question he resolves in the negative, and he proceeds to explain the causes of this deficient population. According to his hypothesis, the state of agriculture affords in every country the surest evidence as to the state of the population; but the backwardness of agriculture in most parts of Europe sufficiently indicates that the population is deficient; therefore he infers the defective state of European legislation on these two capital points. The great obstacles to the improvement of agriculture, and, consequently, to the increase of population, he considers to be, 1*st*, the small number of proprietors, and the great number of non-proprietors; 2*dly*, too many large, and too few small properties; 3*dly*, the exorbitant and inalienable possessions of the church in several states; 4*thly*, the excess of the public imposts, and the violent modes of levying them; 5*thly*, to these he adds other causes of less importance, such as the state of most of the regular troops of the European states; also public corruption, and the dissoluteness of private morals. The progress of agriculture, the great source of wealth as well as of population, may also be obstructed by a bad political administration, by bad laws, or by those causes which occasion a great influx of inhabitants to the respective capitals of the different states. It belongs to a pure system of legislation to remove some of these obstacles, and to counterbalance such others as are inevitable, by suitable encouragements. Having discussed these momentous questions, he next enters into a comprehensive survey of the other sources of riches, namely, arts, manufactures, and commerce, and points out how these may be obstructed by at faulty legislation, and, at the same time, the means by which such obstructions may be removed. In order fully to comprehend the merits of these performances, we must consider that all the faults which the author reprehends were committed by his own government; a circumstance which imposed on him the delicate task of stating obnoxious truths with freedom and boldness, and, at the same time, without giving unnecessary offence. So well, however, did he appreciate the views of those whom it was his wish to enlighten, that he was immediately promoted by the king to a commandery in the royal order of Constantine. In 1783 he married a Hungarian lady of noble birth, who was entrusted with the education of the second daughter of the king, and who to outward attractions united the gift of a sound judgment and an agreeable disposition. That he might the more freely enjoy domestic happiness, and at the

same time have leisure for the composition of his work, on which he became every day more intent, he resigned, with the consent of the king, all his military employments and his office at court, and retired to a country-seat about 20 miles from Naples. In the same year he published his third book, relating entirely to the principles of criminal jurisprudence. In these discussions he maintains the same tone of decision and independence as before. Abuses are freely pointed out, and the defects of the penal code, and the forms of criminal procedure, are fairly exposed. In thus pointing out those defects in the domestic administration of his government, Filangieri excited the hatred of an interested and powerful class; and a proposition which he made in his third book, for the reformation of abuses in the Roman Catholic Church, drew down upon his work the censure of some of the ecclesiastical tribunals. In 1785, however, he published the fifth, sixth, and seventh volumes of his work, which comprehended his fourth book. These were devoted to the consideration of education, morals, and public instruction; and though on these important points we may be occasionally disposed to question his views, we must nevertheless admire his mild and philosophical spirit still opposed to every excess, his extensive knowledge, and his happy talent of arranging and combining it for the illustration of his argument; his animated, flowing, and perspicuous style; and, above all, that rectitude and philanthropy which are diffused over all his reasonings. His fifth book, which treated of the laws relative to religion, was soon afterwards published. But his health was now considerably impaired, owing to an excess of application, so that the remainder of his work advanced but slowly; and other interruptions soon followed. In the year 1787 he was called by the new king, Ferdinand IV., to the supreme council of finance. He returned to Naples, and from that time was wholly engrossed with the important business of this office. His health, already injured, was soon completely broken by severe and active application; and several domestic misfortunes, operating upon a mind of deep sensibility, at last threw him into a state of melancholy. He finally retired from all business into the country, where he soon afterwards became seriously ill, and on the 21st of July 1788 he expired. Before his death he had finished the eighth volume of his work, containing the first part of the fifth book, in which he treats of the different systems of religion that preceded Christianity. Of the second part of the same book he had only made a rude sketch, in which were noted down the principal subjects of discussion; namely, the advantages of Christianity and the dangers of superstition; the inconveniences of mixing spiritual with temporal concerns; the excessive riches of the clergy, and the immense increase of their power. He was also to examine the foundation of ecclesiastical rights, and to present, in a new system of legislation, a remedy for the abuses which he pointed out. A chapter on toleration would have terminated this book. In his sixth book he proposed to treat of the laws relative to property; and in his seventh and last, of the nature of the paternal power and the government of families. He had also other important works in contemplation when his course was terminated by death. Filangieri, besides some of the rarest gifts of genius, was endowed by nature with the additional advantage of a most imposing presence. His manners were eminently graceful and dignified. His countenance bore the traces of habitual reflection, and of deep sensibility, mingled with an expression of soft melancholy. In private life nothing could exceed the simplicity of his character, except the animation and interest of his conversation. See *La Scienza della Legislazione*, Livorno, 1807, 5 tomes 8vo. This is the last Italian edition of Filangieri's great work. There is a French translation in 7 vols. 8vo, published at Paris in 1798, from the Neapolitan edition of 1784. The first two books have been translated into English, under the title of *The Science of Legislation*, from the Italian of Filangieri, and published in 2 vols. 8vo, Lond. 1806. (D. B—N.)

FILBERT, the fruit of the cultivated hazel. See HAZEL.

FILE, a well-known instrument of steel for cutting and abrading metal, ivory, wood, &c. Files are of various forms, sizes, and cuts, according to the uses to which they are to be applied. When the surface is cut in transverse furrows by a straight sharp-edged chisel and mallet, the instrument is properly called a file; but when it is raised by a triangular punch, it is termed a rasp. This last kind is chiefly employed for rubbing wood and horn. The larger kinds of files are made of blistered steel; but the small and fine files of cast steel. Various ingenious machines have been contrived for cutting the teeth of files, but these have not hitherto succeeded so well as to supersede file-making by the hand. After the file has been cut it must undergo the process of tempering. This is said to be well effected in the following manner: A saturated solution of common salt, stiffened to the consistence of cream with ale grounds, or with any cheap farinaceous matter, such as bean-flour (some use well-dried chimney-soot), is to be spread over the file, in order to preserve its surface from oxidation during the process; it is then uniformly heated in a coke or charcoal fire to a cherry-red colour; and on its removal from the fire it is to be suddenly quenched in cold and pure spring water. It is subsequently cleaned with charcoal and a rag; after which it is laid up in wheat bran to preserve it from rust. When the file is intended to cut iron or steel, it is found preferable to substitute animal carbon for the grounds or farinaceous matter mentioned above. This will give even to iron a superficial hardness sufficient for any kind of file.

FILIAL PIETY. Ancient history furnishes many extraordinary instances of this amiable virtue.

The Roman dictator T. Manlius, having exercised great cruelty over the citizens, was cited at the expiration of his office to answer for his conduct. Among a number of things laid to his charge, he was accused of treating with barbarity one of his own sons. All were highly exasperated against Manlius, excepting the son himself, who, under the greatest concern lest he should furnish grounds of accusation against his father, resolved to put a stop to the proceedings. Going to the house of the tribune Pomponius, who had accused his father, while Pomponius was yet in bed, he was immediately admitted by the tribune, who did not doubt but he was come to discover some new instances of his father's severity; but young Manlius drew out a dagger and declared he would stab Pomponius to the heart if he did not swear, in the form he should dictate, never to hold the assembly of the people for accusing his father. Pomponius, when he saw the dagger glittering at his breast, was compelled to yield, and took the oath demanded of him.

Amongst the multitude of persons who were proscribed at Rome under the second triumvirate, were Cicero and his brother Quintus. But the latter found means to conceal himself so effectually at home, that the soldiers could not discover him. Enraged at their disappointment, they put his son to the question, in order to make him disclose the place of his father's concealment; but filial affection remained proof against the most exquisite tortures. An involuntary sigh, and sometimes a deep groan, was all that could be extorted from the youth. Quintus, who was close at hand, when he heard the sighs and groans of a son expiring in tortures to save his life, quitted his place of concealment, and, presenting himself to the assassins, beseeched them to dismiss the innocent youth, and to take his life instead; but the only answer to this appeal was that they must both die. Then a new contest of tenderness arose

who should die first; but this the assassins soon decided, by beheading them both at the same time.

Epaminondas, in the midst of the applause bestowed on him after his splendid victory over the Spartans at Leuctra, with an unaffected simplicity that marked the greatness of his character, observed—"My joy arises from my sense of that which the news of my victory will give my father and my mother."

Among an incredible number of illustrious persons who were put to death by the tyrant Nero, was Barea Soranus, a man noted for his justice and integrity. During his confinement, his daughter Servilia was apprehended on the charge that she had converted into money all her ornaments and jewels, to defray the expense of consulting magicians. To this the young Servilia with tears replied that she had indeed consulted magicians, but for the sole purpose of discovering whether the emperor and senate would afford protection and safety to her beloved parent against his accusers. "With this view," said she, "I presented the diviners with my jewels, apparel, and other ornaments, as I would have presented my blood and my life, could my blood and life have procured my father's liberty. If this be a crime, my father was an utter stranger to it, I alone am the delinquent." Notwithstanding this affecting appeal, she was condemned to die along with her father, but in what manner history is silent.

Valerius Maximus likewise mentions a very singular circumstance connected with this subject. A woman of illustrious birth had been condemned to be strangled. But the jailor who was ordered to execute her, being struck with compassion, resolved rather to let her perish of hunger. He also permitted her daughter to visit her, taking care, however, that the former brought nothing in the shape of sustenance. As this continued many days, he was surprised that the prisoner should live so long; but having narrowly watched the daughter, he discovered that she nourished her mother with her own milk. On the fact being made known, the criminal was pardoned, and a decree was passed that the mother and daughter should be maintained for the rest of their lives at the public expense.

The same author gives a similar instance of filial piety in a young woman called Xantippe towards her aged father Cimonus, likewise confined in prison, and which is commonly known by the name of the *Roman charity*. Both these instances appeared so extraordinary to that people, that they could only account for them by supposing that the love of children to their parents was the first law of nature. *Putaret aliquis*, says the author cited, *hoc contra naturam factum esse, nisi prima naturæ lex esset diligere parentes.*

FILIBEG, or PHILIBEG. See PHILIBEG.

FILICAJA, VINCENZO DA, a celebrated Italian poet, descended of a noble family of Florence, was born in that city on the 30th of December 1642. He commenced his studies under the Jesuits at Florence, and completed them in the university of Pisa. Grecian and Roman antiquity, philosophy, theology, and jurisprudence, were successively the objects of his study; poesy served merely as a relaxation from severer pursuits. Like most young devotees of the muses, he began with amatory verses; but the lady whom he loved and celebrated having died in the flower of her age, he burned all the verses which he had inscribed to her, and resolved henceforth to sing only heroic or sacred themes, a resolution which he most religiously observed. Having returned to Florence, after a residence of about five years at Pisa, he was received into the academy Della Crusca, and, in a short time, married a daughter of the senator Scipio Capponi; but as this lady brought him little fortune, and his own means were limited, he withdrew entirely from the world on the death of his father, and established himself in the country, where he divided his time between his studies, the education of his children, and the contemplation of the wonders of nature and its Author. He every day composed verses either in Latin or Italian, which he submitted to the judgment of his friends, and improved according to the advice which they gave, without any desire for publication, or indeed any other object than that of exercising his own powers. But a memorable occurrence drew him from the voluntary obscurity in which he had buried himself. Vienna, besieged by an army of 200,000 Turks, was delivered by John Sobieski, king of Poland, and by Charles, afterwards fifth Duke of Lorraine. This great event, which saved Christendom from the most imminent danger, excited the enthusiasm of Filicaja, who, in a magnificent *canzone* or ode, celebrated the victory of the Christian armies; he also addressed a second to the Emperor Leopold I., a third to the King of Poland, a fourth to the Duke of Lorraine, and a fifth to the God of Armies; and, the Ottomans having been entirely defeated in another battle, he celebrated this new triumph in a sixth ode, which is perhaps the most beautiful of all. These six triumphal odes excited universal admiration. The grand duke, of his own accord, sent copies of them to the princes whose exploits were commemorated, and from the latter the author received the most flattering acknowledgments. But as the copies of his odes became daily deformed by new errors, in proportion as they were multiplied, his friends at length obtained permission to print them. They accordingly appeared at Florence in 1684, in 4to; and Filicaja was, almost in spite of himself, placed in the first rank of Italian lyric poets. Another great ode, which he addressed the same year to Queen Christina of Sweden, fully supported the reputation which he had gained by his former productions. This princess, who then exhibited in private life the generosity of a sovereign, did not confine herself to a mere expression of her satisfaction, or corresponding with the author, or admitting him into the academy which she had formed at Rome of men most distinguished in poetry and letters: being informed of the depressed state of his circumstances, she in some sort adopted his two sons, undertook to defray the expense of their education, and exacted from their father, as the only expression of his gratitude, that he would maintain the most profound silence, not choosing, as she said, to have to blush before the public for having done so little to serve a man who had so many claims to her esteem. But a severe malady with which he was seized some years afterwards, was followed by another subject of affliction, which he felt much more sensibly; he lost his eldest son, who had been appointed page to the grand duke after the death of the queen his benefactress. This bereavement, which he bore with Christian fortitude, fixed on him the particular attention of the prince, who, interested in his fortune, conferred on him the dignity of senator, and soon afterwards appointed him ducal commissary of Volterra, then commissary of Pisa, and, lastly, secretary *au tirage* to the magistrates, an important office, which gave him immediate access to the prince, and initiated him in the secrets of the government. Filicaja, in all his employments, secured at once the gratitude of the public, the attachment of those under him, and the esteem of his sovereign. Neither the multiplicity of his occupations, nor the progress of age, however, prevented him from dedicating several hours each day to the cultivation of letters and the exercise of his poetical talent; but as his piety, which had always been great, increased with his years, he at length confined his reading to religious books, and treated only of sacred subjects. Nevertheless, he had resolved to collect all his pieces, to revise and correct them anew, and to publish himself a complete edition of his lyrical compositions; but, whilst occupied with this undertaking, in which he had made considerable progress, he was seized with a violent affection in the chest, which in a few days put a period to his life. He died at Florence on the 24th of September

1707, in the sixty-fifth year of his age, and was interred in the family vault in the church of St Peter, where his son Scipio erected a monument to his memory. The edition of his poetical works in Italian, which he was preparing, and had even begun to print at the time of his death, was also speedily published by the same son, who dedicated it to the Grand Duke Cosmo III., under the title of *Poesie Toscane di Vincenzo da Filicaja, senatore Fiorentino et accademico della Crusca*, Florence, 1707, in 4to. They were reprinted in 1720, with a life of the author, by Thomas Bonaventuri, a Florentine; which life had previously appeared in the second volume of the *Vite degli Arcadi Illustri*. But a more valuable though less beautiful edition, from which all the subsequent editions have been taken, is that of Venice, 1762, in two volumes 8vo; the first of which contains the *Poesie Toscane*, and the second the Latin verses of the same author, there for the first time collected from the different publications in which they had been previously scattered. There are subjoined some pieces in prose of inferior interest, if we except a literary correspondence of Filicaja with Francesco Redi, Menzini, and Gori, who shared with him the glory of having, in a corrupt age, remained faithful to the principles of good taste and sound literature. The *canzoni*, to which we have above referred, are perhaps the most remarkable compositions in this collection; but some of the other pieces are not inferior to these either in the dignity of the subject or the majesty and force of the style; and several of his *Sonnets* are worthy of these beautiful odes. Is there an Italian heart that can be insensible to the deep patriotic feeling, expressed with such a mournful and affecting sublimity, in the well-known sonnet, commencing

> Italia, Italia, O tu cui feo la sorte
> Dono infelice di bellezza, &c.;

one of the most perfect compositions of the kind in existence, and which, though it consists of only fourteen verses, will sustain a comparison with the most celebrated lyrical effusions, ancient or modern? We subjoin a happy translation.

> "Italia! thou to whom in evil hour
> The fatal boon of beauty nature gave,
> Yet on thy front the sentence did engrave,
> That ceaseless wo should be thy only dower!
> Ah! were that beauty less, or more thy power!
> That he who now compels thee to his arms
> Might gaze with cold indifference on thy charms,
> Or tremble at thine eye's indignant lower;
> Thou shouldst not then behold in glittering line
> From the high Alps embattled throngs descend,
> And Gallic foes pollute thy Po's clear wave;
> Nor, whilst encompassed close by spears not thine,
> Shouldst thou by foreign hands thy rights defend,
> Conquering or conquered, evermore a slave."

FILIGREE or FILLAGREE (Ital. *filigrano*; Lat. *filum* a thread, and *granum* a grain); a very delicate kind of ornamental work in gold or silver, wrought in the manner of little threads, or threads and grains intermixed. Filigree work is of Eastern origin, and was first introduced into Europe by the Italians. In Sumatra, manufactures of this kind have been carried to the highest degree of perfection, and yet the tools employed are exceedingly coarse and clumsy. These are generally rudely and inartificially formed from any piece of old iron. A piece of iron hoop suffices for making the wire-drawing instrument; an old hammer head, stuck in a block, serves as an anvil; and two old nails, tied together at one end, will suffice for a pair of compasses. The gold is melted in a piece of *preeoo* or earthen rice-pot, or sometimes in a crucible of ordinary clay. In general no bellows are used, but the fire is blown with the mouth, through a joint of bamboo; and if the quantity of metal to be melted is considerable, three or four persons sit round the furnace, which is an old broken quallee or iron pot, and blow together. At Padang, where the manufacture is most considerable, they have adopted the Chinese bellows. The method of drawing the wire differs but little from that which is used by European workmen. When drawn to a sufficient fineness, it is flattened by beating it on the anvil; and when flattened, a twist is given to it by rubbing it on a block of wood with a flat stick. After twisting they again beat it upon the anvil, and thus it becomes flattened wire with indented edges. The end of the wire is folded down with a pair of pincers, and thus is formed a leaf, or element of a flower, which is cut off. The end is again folded and cut off, till they have a sufficient number of leaves, which are laid on singly. Patterns of the flowers or foliage, in which there is seldom much variety, are prepared on paper of the size of the gold plate on which the filigree is to be laid. According to these, they begin to dispose on the plate the larger compartments of the foliage; for which they use plain flattened wire of a larger size, and fill it up with the leaves before mentioned. In order to fix the work, they employ a gelatinous substance made of the berry called *boca sago*, ground to a pulp on a rough stone. After the leaves have been all placed in order, and stuck on bit by bit, a solder is prepared of gold filings and borax moistened with water, which is strewed over the plate, when it is put in the fire for a short time, and the whole becomes united. This kind of work on a gold plate is called *carrang papan;* but when the work is open, it is called *carrang trouse*. In executing the latter, the foliage is laid out upon a card, or soft kind of wood, and stuck on, as before described, with the sago berry; and the work, when finished, being strewed over with the solder, is put into the fire, when the card or soft wood burning away, the gold remains connected. If the piece be large it is soldered at several times. In the manufacture of badjoo buttons, they first make the lower part flat, and having a mould formed of a piece of buffalo's horn, indented to several sizes, each like one half of a bullet mould, they lay their work over one of these holes, and with a horn punch press it into the form of a button; after which they complete the upper part. When the filigree is finished they cleanse it by boiling it in water with common salt and alum, or sometimes lime juice; and in order to give it that fine purple colour which they called *sapo*, they boil it in water mixed with brimstone. The manner of making the little balls with which their works are sometimes ornamented, is simple. They take a piece of charcoal, and having cut it flat and smooth, make in it a small hole, which they fill with gold dust, and this being melted in the fire becomes a little ball. They are very inexpert at finishing and polishing the plain parts, hinges, screws, and the like, being in this as much excelled by the European artists as the latter fall short of them in the fineness and minuteness of the foliage. The Chinese also make filigree, mostly of silver, which looks elegant, but wants the extraordinary delicacy of the Malay work. The price of the workmanship depends upon the difficulty or uncommonness of the pattern. In some articles of usual demand it does not exceed one-third of the value of the gold, but in matters of fancy it is generally equal to that of the metal.

FILIPPO D'ARGIRO, SAN, the ancient *Agyrium*, a town in the province of Catania, Sicily, situated on the summit of a lofty isolated hill near the centre of the island, and 32 miles W.N.W. of Catania. It has numerous churches and convents, and the vicinity is noted for producing the best saffron in Sicily. Agyrium was the birthplace of Diodorus Siculus. Pop. 7000.

FILLET, *in Carpentry*, is applied to a small piece to which a board, joist, quarter, &c. is nailed. *In architecture* fillet is of very frequent occurrence, and is applied to a flat rectangular moulding. It divides or terminates other mouldings, as in the cavetto surmounted with a fillet; in

Filter. the fluting of columns which are divided by a fillet; and in entablatures.

FILTER, an instrument or apparatus contrived for clearing liquids from any impurities mechanically combined with them. Filters are of various kinds, according to the nature of the liquor requiring to be clarified; but they all act on the same general principle, namely, straining the liquor by passing it through earth or other porous material; the process being thus exactly analogous to that of sifting, as used for powder or other dry substances. The operation of filtering is extensively used in chemistry and the arts, and also in purifying water for domestic purposes, and for the use of ships in long voyages; and hence the construction of artificial filters on a large scale for the supply of towns and cities with pure water becomes a very nice and difficult operation, and now forms an important branch of civil engineering. The pureness of spring water arises entirely from a process of filtration. Such water generally issues from a considerable depth beneath the surface of the ground, as is evident from the force with which it is discharged, and the equable temperature which it preserves throughout the year, being cool in summer, and in winter never freezing. Hence, in its course from the surface downwards, it must pass through a variety of soils, subsoils, and porous rocky strata; and it is by the perfect straining which it receives in percolating through such vast masses of filtering materials as must occur in the bowels of the earth, that it comes out at last with that admirable purity and transparency which we observe. But notwithstanding of this, spring water contracts, often among the rocks and minerals with which it comes in contact, various impurities, which become chemically dissolved in it, and from which it cannot be freed by filtration or any other mechanical process. It becomes often, therefore, unfit on this account for domestic use or the purposes of the arts, and is rarely equal, and never superior, to rain or river water properly filtered. The great importance of this operation, therefore, is evident, more especially from the frequent and serious failures which have taken place. But it may be better to defer the consideration of this branch of the subject till it can be resumed along with other hydraulic operations. See WATER-WORKS.

Water filters for domestic use. On a smaller scale, for domestic use, water filters have at different times been brought forward, and for many of them patents taken out. But as they are all very similar in principle, and none appears greatly distinguished above the rest, it is unnecessary to enter into a minute description of them. They are all liable to the objection of clogging up, and getting foul in the course of time. But if regularly cleaned, any of them will answer the purpose sufficiently well, the process of filtration being so simple and so easily effected. Several ingenious plans have been proposed for self-cleaning filters; the water, for instance, being made to ascend, or to pass alternately in opposite directions, and thus carry off the impurities by the process itself. But as none of these have succeeded completely, it will be found most convenient in small filters to clean them regularly; and those are therefore to be preferred which afford the means of doing this most conveniently.

Filtering materials. In these filters the filtering material generally used is gravel, sand, porous stone, or unglazed earthenware. Charcoal is sometimes added, but this is more for its antiseptic and purifying quality, and is only necessary in the case of fetid or very impure water. Gravel, though the best of all materials on a large scale, is rather coarse in itself for small filters. But where it occurs in nature in very thick beds, the large mass of material makes up for the coarseness of the grain; and many instances occur where springs from this source are scarcely inferior in purity to distilled water. But in small filters it requires a bed of sand above it to detain the impurities. Sand is perhaps, after all, the best filtering material; it should, however, be clean sea or river sand, with no tincture of iron; this last is indicated by its reddish colour, which, if deep, will communicate an iron taint to the water, a circumstance harmless enough in itself for most domestic uses, but very prejudicial for the purposes of bleaching, paper-making, &c. in the arts.

Sand and gravel filters. In filters constructed with gravel or sand, all the apparatus that is necessary is a vessel to contain the filtering material, with a space above for holding a quantity of the water to be filtered, and a vessel below for receiving the filtered water. A simple and convenient apparatus of this kind was contrived by Messrs Hearman and Dearn, potters, Redriff, described in Nicholson's *Journal*, vol. viii., and represented in Plate CCLVIII. fig. 1, which exhibits the whole apparatus, and shows, in fig. 2, a shaded section. A is a vessel of stone-ware perforated with holes, *m*, at bottom, upon which coarse gravel, *h*, is laid, and on that again a stratum of fine gravel, and, lastly, fine sand, *g*. Or, otherwise, the bottom may be covered with a coarse cloth, which will render the graduated fineness of the gravel and sand less necessary. Upon the top of the sand is laid a perforated and loaded board or plate of earthenware, to prevent the sand from being disturbed when the water is poured in. B is a lower vessel, into which the filtered water from A drops, together with any sand that may escape from above. The clear water flows out through the neck *ac* into the vessel *d* for use.

On this plan an excellent filtering apparatus may be constructed at little expense, and in various ways, according to the means or conveniencies most readily at hand; and the sand and gravel possess a decided advantage over filtering stones or other materials, from the great facility of cleaning, the latter being liable, from long use and the impurities lodging in their pores, to give the water an unpleasant taint.

A very simple arrangement in the above plan is to have a cylindrical jar of earthenware, as at fig. 5, with two partitions or false bottoms, dividing the height into three equal portions, the partitions resting each on a shoulder formed all round on the jar, or otherwise supported; the middle division for the filtering material, the upper one for the water to be filtered, and the lower one for containing the filtered water, with a stop-cock for drawing it off at pleasure, and a vent or opening at the top for the admission and discharge of air. The stop-cock must be placed three or four inches from the bottom, to allow full space for any sand or other material to deposit in the bottom; and the air vent must be carried up by a small pipe to the top of the jar, to prevent the water ever rising and overflowing by it. The partitions are made of earthenware, with a number of small holes to allow the water to descend. If sand only is used, it will be necessary to spread a layer or two of cloth under it, to prevent the sand getting through the openings. But if gravel can be had, it will be better to lay a bed of this, of two inches or more in thickness, on the bottom, and the sand above it. After the sand is filled in to the height of the upper partition, this is placed on as a cover, which having also a number of small openings in it, the water flows from the upper division downwards. The cover should press on the top of the sand, in order to prevent its being disturbed by the entrance of the water, or a layer of gravel should be placed on the top of the sand. If a layer or two of cloth be laid over the partition, it will serve to detain some of the impurities; and being frequently washed, it will make the filter continue longer clean. In order to clean this filter it is only necessary to remove the upper partition, take out the upper stratum of sand to the depth of two or three inches, wash it thoroughly, and replace it; or, if sand can be had readily, let the whole be replaced with a fresh quantity, clean and pure. This is,

on the whole, a very simple, perfect, economical, and convenient filter. It may be constructed of wood or other convenient material, and is both very easily formed, and easily kept clean and in order; and by varying the thickness of the bed of sand, it can be adapted to the exact degree of filtration required. The vessel also admits of any ornamental shape which taste may direct; and several elegant figures of this kind, contrived by the manufacturers, are shown at the bottom of the plate. If the lower division also were left unglazed and porous, an evaporation would go on from the outside, so that in summer it would act as a cooler as well as a filterer. Should much sediment be found collecting in the lower vessel, perhaps it would be better to place the whole apparatus upon a second jar, so wide as to allow the first to stand over it, and having a pipe in the bottom rising nearly to the top of the vessel, and open at the top. The filtered water would flow over this, and descend into the lower vessel, which being detached, could always be kept perfectly clean in the bottom. The upper end of the pipe should be covered with a fold or two of cloth. An ingenious plan, introduced by Mr Parkes, chemist, for drawing off the water in the reservoir of a filtering or purifying apparatus, though applied rather on a larger scale, might often be used with advantage in smaller filters, such as those for bleachers, paper-makers, and others. It is represented at fig. 6, and consists in connecting the stop-cock for the discharge of the water with a pipe and flexible joint terminating in a rose-head and floating ball, which keeps the head always immersed a little under water, and thus discharges it from near the surface, although the level of the water may vary considerably. The water here is also let in, not directly into the reservoir, but by an upright pipe having a funnel at the top, and descending to near the bottom, which causes the water to enter below, where it must deposit any impurity before this can rise to the surface.

Filtering by descent and ascent.

In the sand and gravel filters here described, the water descends during the whole of the process, and this causes a slight tendency to carry minute particles of sand or other impurities along with it. To remedy this defect, various plans have been proposed for making the water, after descending, again ascend; and this plan certainly possesses advantages, and is a decided improvement on the other. A very neat contrivance of this kind is that proposed by Professor Parrot of Paris, in Nicholson's *Journal*, and is represented at fig. 3.

By Professor Parrot.

It consists simply of an inverted siphon, which could be easily made of lead, having the bend filled with sand, and being covered on the top with gravel in each branch. The water entering the longer branch from a reservoir, passes through the sand, and rising up, is discharged at the other end, which should be three inches below the level of the first. When the section of the tube is four inches by two, and eighteen inches the length of sand, it was calculated that six Paris pints of pure water would be passed in an hour.

By Sir H. Englefield.

Another plan, proposed by Sir Henry Englefield, in the same work, is shown at fig. 4. It consists of a conical vessel placed within the one containing the sand, and allowing the water to descend on the inner vessel, and ascend again in the outer one.

But the simplest mode of effecting the ascent of the water is merely to divide the jar or filtering vessel by a vertical partition, open at the bottom. The water being then poured into the one side, descends to the bottom, passes under the partition into the other side, and ascends to the same level at which it entered, and can then be drawn off by a stop-cock or other means at pleasure. In that case a single vessel only is wanted, and contains in itself the means of holding separately the filtering material, the water to be filtered, and the water after filtration. Upon the whole, this appears by far the simplest, most perfect, most economical, and most convenient filter of this, or perhaps of any kind, that can be contrived. All that is necessary is to have a pretty deep vessel of earthenware, wood, or other material; a tub or barrel will answer perfectly. Put a vertical partition in the middle, reaching nearly to the bottom, fill it half or three fourths full of sand, with a layer of gravel on the top, and it is ready for use. It may be found convenient, to prevent the gravel being disturbed, to place a cover over it, with holes. The water may either be drawn directly from the pure side with jugs, or let off by a stop-cock. Instead of sand and gravel, some have proposed to use charcoal, either by itself or in combination with the others; and an apparatus of this kind was contrived by Mr John Isaak Hawkins. It is only, however, when the water has an impure taint, which cannot be removed by sand, that the charcoal should be resorted to, as it is more expensive, and more difficult to be cleaned. In long voyages, however, charcoal, as proposed by Hawkins, may, in conjunction with sand, be found very useful.

Charcoal filter by Mr Hawkins.

Filtering by ascent alone.

Instead of the water descending and then ascending, several ingenious methods have been contrived where the water only ascends through the filter, being let in below, and forced upwards by the pressure of an external head of water. The advantage of this is, that the filter can be cleaned by letting the water return and run out at the place where it usually enters. These plans, however, on a small scale, are hardly ever found to supersede cleaning. On this principle was the patent granted in 1791 to Mr Peacock, which he intended for small filters as well as those on a large scale. His apparatus consisted of a vessel of wood, lead, or other materials, of any shape or dimensions required, divided near the bottom by a horizontal grate or partition, upon which the filtering medium was spread in layers, beginning with the coarsest and ending with the fine. The lower division had a communication with a more elevated reservoir, from which the water flowed, and rose through the filtering bed. This consisted of gravel, sand, broken and pulverized glass or pottery, all well washed and sifted with sieves. On a similar principle Mr Bramah had a patent for various modes of conveying and drawing off beer and other liquors, in which he describes a filtering apparatus which he proposed to place in the pipes to conduct the liquor. This was a cylindrical vessel, made of copper tinned within, or of any other materials; the upper end was closed by a lid screwed on by a flange, and the lower end terminated in a cone; a pipe was inserted into the vessel near the lower part, to introduce the liquor; and from near the upper end a similar pipe proceeded to convey it away. Between these two was fixed the filtering floor, consisting of flannel, sand in bags, sponges or other similar substances, which were spread upon a horizontal plate pierced full of small holes, and fixed in the cylinder above the filtering substance; and another similar plate was fixed and screwed down to confine it. The liquor was introduced by the lower pipe by means of a pump or otherwise, and ascending through the filtering floor, passed off in a clarified state; the impurities which are separated collect in the conical bottom of the cylindrical vessel, whence they can be drawn by a cock. This contrivance is adapted to give a slight filtration to a great quantity of liquor, such as beer; and Mr Collier, in a patent for the purification of oils, claimed the principle of filtering *per ascensum* combined with hydrostatic pressure.

Mr Peacock.

Mr Bramah.

Mr Collier.

Filtering stones.

Such are the different contrivances for filtering water, where sand and gravel are the materials; but notwithstanding their simplicity, filters of porous stone are those which have hitherto been most generally in use. The

Filter.

stones are procured from beds of sandstone, and sometimes a kind of limestone. They are found in Northamptonshire, Derbyshire, and other parts of England, and are often imported from the island of Teneriffe. The construction of the filter is extremely simple. A thick bowl or basin is formed of the stone, and mounted in a frame. The foul water, being poured into the basin, passes slowly through the substance of the stone, and drops into a receptacle below, in a perfectly transparent state. When the water is foul, a small quantity of mud or slime is found to collect at the bottom of the basin, and must occasionally be cleared out; but in the course of time the more minute impurities will insinuate themselves into the pores of the stone, and at last clog up the passage of the water. This is remedied by chipping away the interior surface of the stone one half or three fourths of an inch, because the impurities do not penetrate deeper into the stone. This will restore its action for a long time.

The basin shape used in these filters is obviously not the most proper, as it leaves an unequal thickness in the bottom for the water to penetrate, and also the pressure of the fluid is unequal. The bottom should be flat and of equal thickness, and in fact it would be much better not to make the stone a reservoir at all; but to use a filtering vessel such as above described, substituting for the sand and gravel a plate of the filtering-stone, of such thickness as may be found best adapted for the nature of the water. If a thin plate also were placed on the top of a thick one, it might then be removed without any trouble when it got foul, and replaced by another, without disturbing the lower mass; or several plates could be laid one above another till the requisite thickness for filtering were obtained.

Filtering upwards.

Instead of pouring the water into the basin and allowing it to filter downwards, the water may be contained in a vessel in which the basin is nearly immersed; and in this way the water will filter partly laterally, but chiefly *per ascensum*, and leave much of its deposit behind, so as to enable the stone to continue longer clean. A filter on this plan was contrived by Mr Moult, and is described in the Transactions of the Society of Arts. The filtered water runs in and fills the basin, from which it can be taken out or let off by a pipe. This principle was also proposed by Mr Collier, and it possesses all the advantages we have already described in filtering upwards with sand; and if it were used with plates of the stone instead of a basin, it would be still more effectual.

Anglesea earthenware filters.

The unglazed earthenware for filtering has been introduced as a substitute for the filtering stones. It is made of different compositions of pottery. The original patent was granted to Mrs Johanna Hempel, potter, Chelsea, in the year 1790. The proportions were four out of nine of tobacco-pipe clay, and five out of nine of coarse sea, river, or pit sand. This was intended for basins not exceeding one gallon. For larger capacities it is liable to fly or crack in the fire. A second composition, therefore, consisted of equal parts of tobacco-pipe clay and sea or river sand; or if this was found insufficient to prevent the cracking, three parts tobacco-pipe clay, one of Stourbridge clay, or clay from the surface of the coal mines, one of Windsor loam, or other loam of equal quality, and four of coarse river or sea sand; or four parts of tobacco-pipe clay, three of sand, and one of the burnt ground clay of which crucibles are made. The above ingredients are brought to the proper basin or bowl shape on the wheel, and are then hardened in the furnace like other pottery ware. The same objection, however, applies here to the basin shape as to the stones; in fact, it would be better to have this composition formed into plates of different thickness, which could then be used, one or more in number, in the filtering vessels, instead of sand or stone; one could be taken out when foul, and another put in, with the utmost facility; and this would certainly be attaining the perfection of a filtering apparatus.

Another still simpler plan would be to have one filtering vessel, with a vertical partition of the porous ware reaching to the bottom. The one half of the vessel would then be filled with the impure and the other with the pure water; and if several of these plates were at hand, one partition could be taken out when foul, and another inserted in its place, or there might be two porous partitions, and a solid one between them. The one would then ascend and run over the top of the solid partition, and again descend and pass through the second porous partition, which would therefore hardly ever require renewal.

A filter, the invention of Mr Robins of London, and for which he took out a patent, has been much recommended to the public. The external appearance is varied according to taste; and figs. 13, 14, 15, already referred to, represent some of the neatest and most elegant patterns. We are not acquainted with the interior construction, but understand it consists of various strata of filtering material, such as we have above described, arranged so as to act with peculiar efficacy. At the top there is a sponge neatly inserted into a recess above the upper partition, which is a very judicious and useful mode of detaining any impurities, and preventing them from getting into the filterer, the sponge being easily taken out and washed from time to time. The patentee, however, claims far higher powers for his invention than that of mere filtration. He states that the interior process involves a *voltaic* action, which decomposes soluble substances, and renders the water equal in purity to distilled water. We confess we have great doubts in regard to this, and think it irreconcilable with any idea of voltaic or chemical action with which we are acquainted. Still we have no doubt, from the various testimonials brought forward, that the filter is a good one. Fig. 14 is about three feet high, and one and a half broad, and is calculated to filter fifty gallons a day; the others in proportion.[1]

From the great success with which water has been purified by filtration, attempts have been made to purify oils in the same manner; and an ingenious apparatus for this purpose was contrived, and a patent taken out, by Mr Joshua Collier, applicable also to water and other liquids, and of which an account will be found in the *Repertory of Arts*, vol. x. But in oils there is generally so many impurities, chemically or otherwise united, that filtration can do little for their purification. Charcoal is the substance chiefly employed. A filtering machine contrived by Mr Innes of Edinburgh is said to answer well for oils and other fluids. By it the fluid is forced through the pores of wood by the action of a forcing-pump. Such a degree of pressure is unnecessary for water; but for oil, quicksilver, and other valuable fluids, it appears certainly well adapted.

Filtration in chemistry.

Filtration is much used in chemical processes. The materials employed are unsized paper, cloth, flannel, tow, sponge, sand, pulverized glass, flints, porous stones, earthenware, &c. In fig. 12 is represented a neat little filtering apparatus constructed by Mr Parkes; and the following remarks and directions are taken from Mr Faraday's excellent work on Chemical Manipulation. "Of the above substances, the first is almost exclusively in use at the laboratory, a few of the others now and then being resorted to only on particular occasions.

"Funnels are continually necessary to support the paper through which filtration is to take place. The ordinary funnels required in the laboratory for the passage of fluids answer the purpose very well, but they are of use for supporting filters, when, from their necks being broken off, they are otherwise unserviceable. They may be either of glass or good Wedgewood or other earthenware; those

[1] Besides those already mentioned, there are many excellent filters in common use, but their construction offers nothing to call for a special notice.

of glass are to be preferred, because the progress of the filtration and the state of the filter can be better ascertained in them. Metal funnels should not be allowed in the laboratory.

"The funnels containing filters may be frequently supported by the glass or jar intended to receive the filtered fluid, and at other times by the rings of retort stands. But notwithstanding these facilities, so frequently is the operation required, that a laboratory should be supplied with at least one filtering stand of considerable size. The end of such a stand is represented in fig. 7.

"It is no easy matter for the chemist to obtain unobjectionable filtering paper. It is amongst the thinner varieties of unsized paper, or white blotting-paper, that the chemist will probably find the kind best suited to his purpose.

"Filtering paper should be cut ready for use into different sizes. The simplest filter is made by folding the paper twice in opposite directions, so as to bring the four corners together, and by opening one corner from the other three, so as to produce an irregular conical cavity, as in fig. 8. Such a filter being put into a funnel and then filled with liquid, will immediately permit its passage; but from the similarity of form between the filter and the funnel, and the close adhesion of the former to the latter over by far the greater part of its surface, considerable obstruction is opposed to the passage of the fluid. Much the best expedient for facilitating its passage is so to fold the filter that ribs may exist in the paper itself. For this purpose, the paper is first to be doubled, and in this state is again to be folded in half, each half folded into quarters, and each quarter into eighths, the folds being all on the same side, and radiating at equal distances from the middle of the folded edge to the other edges. Fig. 9 represents the doubled paper thus divided into eight parts. Each eighth is now to be divided into half by folds in the opposite direction, but in lines still originating at the same centre, which makes the doubled piece resemble a child's paper fan, both when closed and when a little open: it is represented by fig. 10. Whilst in this state, the projecting corners should be taken off by a knife; folding the whole up tight like a closed fan, and making the section at about *a*. Having opened it sufficiently to separate the cut edges from each other, it will be found that the paper is equally divided into parts forming alternate external and re-entering angles, except at the two edges *bb*, where two external angles come together. Here the intervening portion of paper between the two contiguous external angles should be folded, by bringing the latter together, and creasing the paper down, so as to form a re-entering angle between them: this should be done at both places. Its appearance when perfectly formed is represented at fig. 11.

For further information on this subject see *Repertory of Arts*; Hempel, vol. ii., p. 230; Collier, vol. x., p. 389; Peacock, vol. xi., p. 221, vol. xiii., p. 140; Nicholson's *Journal*; Hearman and Dearn, vol. viii., p. 126; Parrot, vol. ix., p. 40; Sir H. Englefield, vol. ix., p. 95; Lillach, *Phil. Mag.* vol. vi., p. 240; *Mém. Acad. Par.* 1745, Hist. 82; 1748, Hist. 121; *Machines Approuvées*, tom. vii., p. 280; Gilbert's *Journal der Physik*, vol. xiii., p. 108. (G. B—N.)

FIN. See Ichthyology; and Mammalia, § *Cetacea*.

FINAL CAUSE. See vol. iii., p. 540.

FINALE, a seaport-town of the kingdom of Sardinia, on the Gulf of Genoa, 10 miles N.N.E. of Albenga. It consists of two parts about a mile distant from each other—the one Finale Borgo standing on a hill, the other Finale Marino on the shore. It has some trade in fruits, but the harbour is small and insecure. In the vicinity are numerous ruined forts. Pop. 5000. There is another Finale in the duchy of Modena, on the Panaro, 10 miles from its junction with the Po. It has manufactures of silk and woollen fabrics, and some trade in corn, wine, and hemp. Pop. 7000.

FINANCES, in *Political Economy*, the revenues of a king or state; analogous to the treasury or exchequer of the English, and the *fiscus* of the Romans. The word is derived from the German *finantz*. See Taxation.

FINCH, Heneage, first Earl of Nottingham, and lord high chancellor of England, was the son of Sir Heneage Finch, recorder of London, and born in December 1621. He received his education at Westminster School, and at Christ-Church College, Oxford, of which he was a gentleman commoner; and he studied law in the Inner Temple, where, by his talents and diligence, he became remarkable for great legal acquirements. On the restoration of Charles II. he was made solicitor-general, and created a baronet. He was also appointed reader of the Inner Temple, and chose as his subject the statute of the 39th Elizabeth, concerning the payment and recovery of debts of the crown, which he treated with great force of reason and depth of legal erudition. As solicitor-general, he took an active part in the trials of the regicides; and in 1661 he was chosen member of parliament for the university of Oxford, by the recommendation of Lord Clarendon. In 1667, when Lord Clarendon was impeached for certain alleged high crimes and misdemeanours, Sir Heneage defended him against the charges preferred by his enemies. In 1670 he was appointed attorney-general, and, some years afterwards, lord keeper. He was then raised to the peerage by the style and title of Baron Finch of Daventry, in the county of Northampton; and, in 1675, appointed lord high chancellor of England. He officiated as high steward at the trial of Lord Stafford, who, in the madness of that time, was found guilty of high treason by his peers, on a charge of being concerned in the Popish plot. In 1681 he was created Earl of Nottingham, and died the following year, at his house in Queen Street, Lincoln's-Inn-Fields. Lord Nottingham was distinguished for both sagacity and eloquence; and, though he lived in times when it was difficult to pursue a steady and consistent course, he conducted himself in such a manner as to retain the favour of the court without forfeiting the approbation of the people. "He was a person," says Mr Justice Blackstone, "of the greatest abilities, and most incorrupted integrity; a thorough master and zealous defender of the laws and constitution of his country; and endued with a pervading genius that enabled him to discover and pursue the true spirit of justice, notwithstanding the embarrassments raised by the narrow and technical notions which then prevailed in the courts of law, and the imperfect ideas of redress which had possessed the courts of equity."

In the name of the Earl of Nottingham have been published, 1. Several Speeches and Discourses on the Trials of the Regicides; 2. Speeches Delivered in both Houses of Parliament; 3. Speech at the Sentence of William Viscount Stafford, 7th December 1680; 4. Answers to His Majesty's Command upon several Addresses Presented to His Majesty at Hampton Court, 19th May 1681; 5. The Arguments upon which he made the Decree in the Cause between the Honourable Charles Howard, plaintiff, Henry Duke of Norfolk, Henry Lord Mowbray, his son, Henry Marquis of Dorchester, and Richard Marriot, Esq., defendants, folio; 6. An Argument on the Claim of the Crown to Pardon on Impeachment, folio. He also left in manuscript *Chancery Reports*, and notes on Coke's *Institute*. (J. B—E.)

Finch. See *Fringilla* in index to Ornithology.

FINDHORN, a river of Scotland. See Morayshire.

FINE, in *Law*, has different applications. Until recently it was a very usual species of assurance of lands or tenements, or of anything inheritable, and was so called because it put an *end* to all suits and controversies concerning the same matter. It bound not only the granter himself and his heirs, but also all mankind, whether concerned in the transfer or not, if they failed to put in their claims within the time allotted by law. By the 3d and 4th Will. IV., cap. 74, no fine can be levied after 31st Dec. 1833.

Fine also signifies a sum of money paid for entering lands or tenements let by lease; and sometimes a pecuniary mulct

for an offence committed against the king and his laws, or against the lord of the manor.

FINE ARTS. See ARTS, and EXHIBITION.

FINGAL, king of Morven. See OSSIAN.

FINGAL'S CAVE. See STAFFA.

FINIAL. See glossary to ARCHITECTURE.

FINISTERE, or FINISTERRE, the most western of the French departments, and forming part of the old province of Bretagne, is bounded on the N.W. and S. by the ocean, while on the E. it has the departments of Cotes-du-Nord and Morbihan. It extends from N. Lat. 47. 44. to 48. 47., and from W. Long. 3. 22. to 4. 50.; being 78 miles in length from N. to S. by 63 in width, and having an area of 666,705 hectares, or 2574 square miles. Two chains of hills run nearly parallel from E. to W. through this department, and divide it into three zones of nearly equal extent, conveying the waters in three different directions. North of the Arrez, or more northern of the two chains, the waters of the Douron, Jarleuc, Penzé, Flèche, &c., flow northward to the sea. South of the Noires range the Odet, Aven, Ioste, and Elle, flow southward; while the region inclosed by the two chains having a declination westward, the waters of the Aulne and the Elorn flow into the Brest roads. The rivers are all small, and none of the hills attain a height of 900 feet. The coasts are generally steep and rocky, and indented with numerous bays and inlets, affording some excellent harbours, the principal being those of Brest, Morlaix, Landernau, Quimper, and Douarnenez. The only navigable rivers are the Aulne, Elorn, and Odet. Off the coast lie a number of islands and rocky islets, the principal of which are Ushant and Bas. The climate is temperate, but rather humid; the prevailing winds are the W., S.W., and N.W. Of the 1,647,521 acres contained in this department, 675,142 are arable, 663,678 heath and waste land, 81,055 woods and forests, 101,095 meadow land, and 24,797 gardens, orchards, &c. Though so small a portion of the land is under cultivation, yet the produce of corn is more than sufficient for the population, and would be still greater were more scientific methods pursued in its cultivation. The chief crops are oats, rye, wheat, and barley; flax, hemp, and pulse, of good quality, are also produced. The pasturage being good, considerable attention is given to the rearing of cattle; and the fisheries of the coast, particularly the pilchard fishery, employ a great many hands, and render this department an excellent nursery of seamen for the French navy. Finistère is rich in minerals—iron, coal, lead, bismuth, and zinc mines, are worked; as well as quarries of granite, slate, marble, and porphyry. The lead mines of Poullaouen and Huélgoët are among the largest in France, and the ore extracted yields a considerable quantity of silver. The manufactures are linens, woollens, sailcloth, ropes, paper, leather, earthenware, soda, soap, candles, sugar, &c. Ship-building is carried on at Brest and other of the seaports. Finistere is divided into 5 arrondissements as follows:—

Arrondissements.	Cantons.	Communes.	Pop. in 1851.
Quimper	9	62	117,489
Brest	12	83	204,765
Châteaulin	7	59	105,658
Morlaix	10	58	142,863
Quimperlé	5	20	46,935
Total	43	282	617,710

FINLAND, called by the natives *Suomemna*, the Region of Lakes or Swamps, is a government of Russia, comprising, besides the old Swedish province of Finland, the two Lapmarks of Kami and Torneå, and the district of Wiborg. It lies between N. Lat. 59. 50. and 70. 6., and E. Long. 20. 30. and 32. 45., being bounded on the N. by Norwegian Finmark, by Sweden W. and the Gulf of Bothnia, S. by the Gulf of Finland, and E. by the governments of St Petersburg, Olonetz, and Archangel. It is about 730 miles in length from N. to S., with an average breadth of about 185 miles. The sea-coast of Finland throughout its entire extent presents the same succession of fiords and rocky headlands as characterize the whole seaward frontier of Sweden and Norway. The fiords of Finland, however, are far more limited than those to the west of the Gulf of Bothnia, and seldom exceed a few miles in extent, although their mouths contain an equal number of islands, some of which, as the isles of Sveaborg, have been converted into fortresses of great strength. The coasts of the Bothnian and Finland Gulfs are thickly strewn with rocks of granite and limestone, presenting in some places a labyrinthine archipelago of little islands, rendering the navigation extremely dangerous. The greater portion of the interior is a vast table-land averaging in height from 400 to 600 feet, and interspersed with hills of no great elevation. In the north, however, are the Manselka Mountains, which attain a height of nearly 4000 feet, and stretch southward, though with several interruptions, until they terminate in lofty cliffs on the Gulf of Bothnia. The great mass of the mountains is composed of red granite, and vast quantities of the same rock lie in boulders on the lower grounds, and prove a very serious obstacle to their cultivation. Many of the heights are bare, but the greater part of them being of moderate elevation are covered with forests chiefly of pine; and in combination with the vast number of lakes inclosed by their bases, often form very romantic scenery. The extensive forests are sometimes devastated by the tempests of winter, which seem to find access to their very centres in tornadoes, tearing up by the roots or bending and snapping the largest pines. Frequently also ravages are committed in them by conflagrations occasioned often through the carelessness of the peasants. The interior of Finland is also intersected and broken up by a vast number of lakes, throwing out winding arms and branches in all directions, which, while they offer the greatest facilities for inland navigation, render land travelling circuitous and dangerous. Many of the high roads pass over islands on these lakes, the natural strength of whose situation has been taken advantage of, to cover them with batteries; and some of them, as at Wiborg and Nÿslot, are considered impregnable, save to fraud or famine. The principal of these lakes are Ladoga, the greater portion of which belongs to this government; Lake Saima, which is crowded with islands and discharges its superfluous waters in a series of cataracts into Lake Ladoga, but which is now connected by means of a canal with the Gulf of Finland near Wiborg; and Lake Enara in the extreme north, covering above 1000 square miles, and having its outlet in the Frozen Ocean. The chief rivers are the Uleå, which is navigated by trading vessels though its stream is very rapid; the Cano which passes Biörneborg; the Aurajoki which at Abo is about 100 yards broad; the Kymen which flows into the middle of the Gulf of Finland; and the Torneå which discharges itself at the northern extremity of the Gulf of Bothnia, and forms the present boundary between Sweden and Russia. The climate varies much according to the locality. In Lapmark, in the north, it is polar somewhat modified, and the sun disappears during December and January. Further south at Uleåborg, winter begins in October and continues to May, to which month spring is limited. Summer commences in June and lasts three months, which are generally so hot and dry that the crops, particularly where the soil is of a sandy nature, often suffer from drought. The autumn, like the spring, is confined to one month, and may be said to commence and terminate in September. Even in summer the nights are cold, particularly about the middle of August. During summer, however, the progress of vegetation is remarkably rapid; and there have been instances of grain being sown and reaped in six weeks. In the more southern parts the climate is less severe; the winter being of five or six

Finland.

months' duration. Dense fogs are frequent, and heavy rains take place in autumn. The soil is for the most part stony or sandy; but notwithstanding this it is much more productive then the opposite part of the Scandinavian peninsula, and when in the possession of Sweden it was termed the granary of that country. The principal crops are barley and rye, but owing to the nature of the surface and climate a large portion of the land is fit only for pasture. In the north, where vegetation is almost confined to the growth of moss and lichen, other domestic animals are superseded by the reindeer, of which great herds are kept. In addition to timber (chiefly fir), large quantities of potash, pitch, and rosin are obtained, and form the principal articles of export. The mineral productions are chiefly confined to iron, lead, sulphur, slate, and granite. The first is only wrought to a limited extent for the supply of a few furnaces; wrought iron being now principally imported from Sweden. A great number of excellent granite quarries have been opened, chiefly on the borders of the lakes or sea-coasts to secure the advantage of water carriage. From these are obtained blocks of extraordinary magnitude and beauty, which are employed for architectural and artistic purposes. One of the finest specimens is the monolith obelisk recently erected in St Petersburg to the Emperor Alexander. In its rough state it was 12 feet in diameter, and 80 feet in length. The manufactures of Finland are insignificant. Agriculture, the rearing of cattle, and fishing are the principal occupations of the inhabitants. The coasts present many good harbours, but on account of the long winter they cannot be extensively used. In winter sledges afford an easy and rapid communication with different parts, and even with Sweden across the Gulf of Bothnia. In March 1809, Barclay de Tolly crossed over with a division of the Russian army from Vasa to Umeå in Sweden.

From official documents the returns of the trade of Finland for the year 1848 were in silver rubles of the value of about 3s. 2d., as follows:—

EXPORTS.

To Sweden and Norway	197,942
To other countries	1,946,994
Export duty on the same	38,704
Total	2,183,640

IMPORTS.

From Sweden and Norway	430,366
From other countries	3,123,590
	3,553,956
Deduct import duty thereon	893,500
	2,660,456

Showing an excess in the imports over the exports of 476,816 rubles, which, however, was in part covered by the freight earned by the merchant shipping. The above statements indicate a falling off as compared with former years in the export trade to Norway and Sweden. To these two countries the leading articles of export and their value were—fish 23,569 rubles; hides 8616; beef 24,578; grain 15,083; tallow 30,809; tar 11,483; firewood 11,483. The imports were—books 16,200 rubles; fish 25,228; iron and steel 250,870; sugar 66,418; tobacco 4677; dye-woods and stuffs 23,990. The exports to other countries were also less than in former years; the chief articles were—potash 16,733 rubles; butter 183,409; tar 324,717; wood and timber 921,360. The chief imports from other countries were—medicines 20,914 rubles; cotton 138,318; arrack, rum, brandy, 169,794; coffee 597,708; fruits 106,042; dye-stuffs 134,550; yarn 349,933; iron and steel 89,709; salt 531,665; sugar 544,485; wine 140,528; manufactures wove 666,145.

In 1831 Finland was divided administratively into eight circles or *läns*, which are sub-divided into *fogderier* or districts, and *herads* or bailiwicks. There is a distinct establishment at St Petersburg for the government of this vast province. The governor-general, who resides at Helsingfors, has the superintendence of the military affairs. Finland has a diet composed of the four orders of the nobility, clergy, citizens, and peasantry, and a code of laws and judicial system similar to that of Sweden, but the diet is rarely convoked, except to consent to the imposition of fresh taxes, a senate more recently established having replaced it in the exercise of its functions. The regiments raised in Finland are not promiscuously intermixed with the general forces of the Russian empire; and their fleet, by far the best manned portion of the Russian navy, forms a distinct squadron under the Finnish flag. None but a native Finlander can hold any office of trust in the country. Almost all the inhabitants are Lutherans under the bishops of Abo and Borgo, except in the circle of Wiborg, where they belong to the Russian Church. Public education is in a very backward state. At Helsingfors is a university, transferred from Abo in 1828; and all the towns have schools, but there is a great deficiency of country schools. The majority of the inhabitants are Fins, who call themselves *Suomalans* or *Suomes*, but they are denominated Tschudes by the Russians. They are of middle height, robust, flat-faced, with prominent cheek-bones, light, reddish, or yellowish-brown hair, gray eyes, little beard, and a dull sallow complexion. They are courageous, hospitable, and honest, but obstinate in the extreme, indolent, dirty, and it is said revengeful. Their customs and habits have been handed down from time immemorial, and their costume forcibly bears out the supposition of their being of oriental origin. The peasants wear long loose robes of a coarse woollen manufacture, secured by a silken cincture like the *kummerbund* of the Mussulmans. The eight läns with their areas and populations are as follows, commencing from the south and east:—

	Area.	Population.
Wiborg	16,700	224,701
St Michael	9,271	135,231
Nÿland	5,376	149,714
Tavastehuus	7,112	132,586
Abo	10,626	250,238
Vasa	15,938	199,437
Kuopio	17,039	156,706
Uleåborg	63,415	125,114
Total	145,477	1,373,727

The chief towns of Finland are Helsingfors the present capital, Abo the former capital, Wiborg, Tavastehuus, Vasa, Uleåborg, and Torneå. The Fins were Pagans living under their own independent kings till the twelfth century, about the middle of which Finland was conquered by the Swedes, who introduced Christianity. The province of Wiborg was seized by Peter the Great in 1721, and the remainder of the country was annexed by conquest to the Russian dominions in 1809.—(*Athenæum*, 18th March 1854.)

Finland, Gulf of; Firdusi.

FINLAND, *Gulf of.* See BALTIC.

FIORENZUOLA, a town of Northern Italy, duchy of Parma, on the Emilian way, 18 miles W.N.W. of Parma. The town contains many remains of antiquity, and the sacristy of the collegiate church has some curious relics of ancient art. It is supposed to be the ancient *Fidentia;* and about eight miles to the south were discovered in 1761 the ruins of *Veleia*, buried in the fourth century by the fall of the mountain at the foot of which it was situated. Cardinal Alberoni was born at Fiorenzuola in 1664. Pop. 3000.

FIR. See PLANTING; TIMBER; STRENGTH OF MATERIALS.

FIRDUSI, or, as the name is variously written, FERDUSI or FERDOUSI, ABUL-CASIM MANSOUR, a celebrated Persian poet, was born at Shadab in Khorassan. The date of his birth is not very well known, but from the internal evidence of the *Shah Nameh* may be assigned approximately to the year 930. His father was a gardener in the service of

Fire, Nature of, || Greek Fire.

a wealthy Persian, and from the name of the spot which he cultivated (Firdus or Ferdus, *i. e.* Paradise) it is believed that the young poet derived his name. Firdusi had already passed the prime of life when he left his native village for the court of the Sultan Mahmoud, who at that time lived in the city of Ghazna. Chancing to fall upon an old history of Persia, he perused with the utmost eagerness the old legends of the early wars of that country; and by the advice of Mahmoud he began a complete poetical history of the Persian kings. For thirty years he laboured at this work, encouraged by the sultan, who promised him a thousand pieces of gold for every couplet. At the end of that period, however, he was doomed to be cruelly disappointed. Some of the courtiers had taken umbrage at the severity with which he satirized their intrigues, and had poisoned the mind of Mahmoud against him, so that instead of keeping his promise, that monarch rewarded the poet with silver pieces instead of gold. Enraged at this meanness, Ferdusi quitted the court, leaving behind him a manuscript which he requested should be read to the sultan the first time he felt himself exhausted with fatigue or out of temper. The document in question was a satire on his majesty, which so irritated the monarch, that he persecuted the poet during the remainder of his life, and compelled him to wander from country to country till his death. He first took refuge at Mazanderan. Driven thence he fled to Baghdad, the caliph of which city presented him with a reward equal to that which he ought to have received from the Sultan Mahmoud. But the emissaries of that potentate still continued to persecute him, till a pardon was with difficulty extorted from their master, and the ill-starred poet returned to his native town, where he died in 1020, in the eighty-ninth year of his age. Ferdusi's great work, the *Shah Nameh*, which is a history of the Persian monarchy from its foundation till the year 641 A.D., is of little value in an historical point of view, except in so far as it preserves many of the old traditions of the country. As a poem, however, it still holds a very high place in Oriental literature. This perpetuity of fame is due in an equal degree to the intrinsic poetical merits of the work and the purity of the Persian in which it is written. It is said that no work in the Persian language is so free from foreign admixture as the *Shah Nameh*. No complete copy of the work is known to exist. Several collations of numerous MSS. have been made, though unsuccessfully, with a view to making up a complete text. Of these may be mentioned that made by Dr Lumsden, of which only a part has been published; and that of Mr Macan, published at Calcutta in 1829, in 4 vols. 8vo. An abridgment of the *Shah Nameh* in prose and verse was published by Mr James Atkinson, London, 1833.

FIRE, NATURE OF. See HEAT.

Greek Fire, a kind of artificial or factitious fire, which is said to have been used with wonderful effect in the wars of the Christians and Saracens in the seventh century. Its ingredients are not known, the composition of it having been kept a profound secret; nor do the accounts that have come down to us admit of anything but conjecture as to its nature. From the descriptions of its effects, however, it seems probable that the principal ingredient was naphtha, with the addition of nitre, and perhaps sulphur. The use of naphtha, from its great inflammability, and the difficulty of quenching its flame, may account for the havoc and dismay which the Greek fire is said to have occasioned, and may have given rise to the stories of its burning with greater violence in water than in air, though a sufficient admixture of nitre, by the oxygen it gives out in combustion, might render such a composition for a time almost unextinguishable even by water. We are told too that it was employed with equal effect, by sea and land, in battles or in sieges. "In two sieges," says Gibbon, "the deliverance of Constantinople may be chiefly ascribed to the novelty, the terrors, and the real efficacy of the Greek fire. The important secret of compounding and directing this artificial flame was imparted by Callinicus, a native of Heliopolis in Syria, who deserted from the service of the caliph to that of the emperor. It was either poured from the rampart in large boilers, or launched in red-hot balls of stone and iron, or darted with arrows and javelins, twisted round with flax and tow which had imbibed the inflammable oil; sometimes it was deposited in fire-ships, and was most commonly blown through long tubes of copper, which were planted on the prow of a galley, and fancifully shaped into the mouths of savage monsters that seemed to vomit a stream of liquid and consuming fire. This important art was preserved at Constantinople as the palladium of the state: the galleys and artillery might occasionally be lent to the allies of Rome, but the composition of the Greek fire was concealed with the most jealous scruple. The secret was confined above 400 years to the Romans of the East. It was at length either discovered or stolen by the Mohammedans; and in the holy wars of Syria and Egypt they retorted an invention, contrived against themselves, on the heads of the Christians. The *feu Gregois*, as it is styled by the more early of the French writers, "came flying through the air," says Joinville, "like a winged long-tailed dragon, about the thickness of a hogshead, with the report of thunder and the velocity of lightning; and the darkness of the night was dispelled by this deadly illumination. The use of the Greek fire was continued to the middle of the fourteenth century, when the scientific or casual compound of nitre, sulphur, and charcoal, effected a new revolution in the art of war and the history of mankind."

Fire-Balls.

It should be observed, that in all probability many different inventions have been described under the general name of *Greek fire*. Although the invention has usually been ascribed to Callinicus of Heliopolis, in the reign of Constantine Pogonatus, A.D. 668, it seems highly probable that naphtha (which abounds in many parts of the ancient Persian kingdom, in India, and on the shores of the Caspian) had been applied to the purposes of warfare at a much earlier period by the Oriental nations. This subject has been ably discussed by Dr Macculloch in the *Quarterly Journal of Science, &c.* vol. xiv.

FIRE-BALLS, called also *Bolides* and *Fiery Meteors*, globular masses of fire which appear at a considerable height above the earth, shining occasionally with very great splendour, and sometimes leaving a luminous track behind them. The larger ones in this hemisphere proceed generally from north to south with great velocity, frequently exploding into globes of smaller size, and sometimes vanishing with a report, sometimes without one. They are not unfrequently attended with a discharge of solid compounds of earthy and metallic matters, called meteoric stones, the descent of which, though stubbornly denied for a time, was finally established about the beginning of this century.

These luminous appearances no doubt constituted part of the ancient prodigies, blazing stars or comets, which last they sometimes resemble in being attended with a train; but they sometimes appear with a round and well-defined disk. The first of these of which we have any accurate account was observed by Dr Halley and some other philosophers at different places in the year 1719. From the slight observations they could take of its course, the perpendicular height of this body was computed at about 70 miles above the surface of the earth. The height of others has also been computed, and found to vary from 33 to 100 miles. The velocity at which they travel is estimated at from 5 to 33 miles in a second. One of the most remarkable of these on record appeared on the 18th of August 1783, about nine o'clock in the evening. It was seen to the northward of Zetland, and took a southerly direction over an immense space, being observed in the

southern provinces of France, and, according to one account, at Rome. During its course it frequently changed its shape; sometimes appearing in the form of one ball, sometimes of two or more, sometimes with a train, sometimes without one. It passed over Edinburgh nearly in its zenith, and had then the appearance of a well-defined round body, extremely luminous, and of a greenish colour—the light which it diffused on the ground giving to objects a greenish cast. After passing the zenith it was attended by a train of considerable length, which continually augmented, and at last entirely obliterated the head, so that it looked like a wedge flying with the obtuse end foremost. The motion was not apparently rapid, by reason of its great height: though it must have moved with great velocity, on account of the immense space over which it travelled in a short time. In other places its appearance was very different. At Greenwich we are told that "two bright balls parallel to each other led the way, the diameter of which appeared to be about two feet; and were followed by an expulsion of eight others, not elliptical, seeming gradually to mutilate, for the last was small. Between each two balls a luminous serrated body extended, and at the last a blaze issued which terminated in a point. Minute particles dilated from the whole. The balls were tinted first with a pure bright light, then followed a tender yellow, mixed with azure, red, and green; which, with a coalition of bolder tints, and a reflexion from the other balls, gave the most beautiful rotundity and variation of colours that the human eye could be charmed with. The sudden illumination of the atmosphere, and the form and singular transition of this bright meteor, tended much to make it awful; nevertheless, the amazing vivid appearance of the different balls, and other rich connective parts not very easy to delineate, gave an effect equal to the rainbow in the full zenith of its glory."

Dr Blagden, in a paper on the subject inserted in the seventy-fourth volume of the *Philosophical Transactions*, not only gave a particular account of this and other meteors of the kind, but offered several conjectures as to the probable causes of them. The first thing which occurred to philosophers on this subject was, that the meteors in question were burning bodies rising from the surface of the earth, and flying along the atmosphere with great rapidity. But this hypothesis was soon abandoned, on considering that there was no power known by which such bodies could either be raised to a sufficient height, or projected with the velocity of these meteors. The next hypothesis was, that they did not consist of one single body, but of a train of inflammable vapours, extending a vast way through the atmosphere; which being kindled at one end, displayed the luminous appearances in question by the fire running from one end of the train to the other. To this hypothesis, which was broached by Dr Halley, Dr Blagden objected that no just explanation was given of the nature of the vapours themselves, the manner in which they were raised up, or their regular arrangement in straight lines of such vast extent; or how they could be supposed to burn in such rarefied air. "Indeed," says he, "it is very difficult to conceive how vapours could be prevented, in those regions where there is in a manner no pressure, from spreading out on all sides in consequence of their natural elasticity, and instantly losing that degree of density which seems necessary for inflammation. Besides, it is to be expected, that such trains would sometimes take fire in the middle, and thus present the phenomenon of two meteors at the same time, receding from one another in a direct line."

For these and other reasons the hypothesis of Dr Halley was abandoned, and another substituted in its place. This was, that the meteors in question are permanent solid bodies, not rising from the earth, but revolving round it in very excentric orbits, and thus in their perigee moving with inconceivable rapidity. Another theory supposes that the meteors in question are a kind of bodies which take fire as soon as they come within the atmosphere of the earth. Sir Humphry Davy's discovery that the earths and alkalies are metallic oxides, affords some plausibility to this theory, especially in cases where the meteors are accompanied with the descent of solid bodies to the earth. It has been suggested that the bases of the earths may exist in the meteor in a metallic state, and that when the body arrives within the range of our atmosphere, the strong affinity which it is well known these metallic bases have for oxygen causes them to unite and produce violent combustion. The origin of fire-balls has also been ascribed to the agency of electricity, and there seems little doubt that this is really the true way of accounting for them.

Falling or *shooting stars* are the same phenomena upon a smaller scale. See FALLING STARS, and METEOROLITES. Dispersed through the volumes of Von Humboldt's *Cosmos* the reader will find many curious and interesting observations on these phenomena.

FIRE-ARMS. See GUN-MAKING.

FIRE-DAMP. See DAMPS, and LAMP, *Safety*.

FIRE-ENGINE, a species of forcing pump in which the water is subjected to pressure sufficiently strong to raise it to the required height. Those of the ordinary construction consist of two forcing pumps, wrought by the reciprocating motions of two transverse levers. The water is forced into an air-vessel, by which means the inclosed air is condensed, and by its reaction it forces the water through a moveable pipe, which terminates in a conical form, and is directed upon the flame. Braithwaite's steam fire-engine is an ingenious application of the moving power of steam to the working of fire-engines. The mechanical arrangement of this machine consists of two cylinders of about six inches in diameter, one of them being the steam-cylinder, and the other the water-pump; and they are placed horizontally, so that a parallel motion is easily obtained. An engine of this kind will deliver about 9000 gallons an hour to the height of 90 feet. The time of getting the engine into action from the moment of igniting the fuel (the water being cold) is only 18 minutes. For further observations upon fire-engines, see HYDRODYNAMICS, chap. iii., sec. 2.

FIRE-ESCAPES. See LIFE-PRESERVERS.

FIRE-FLIES. See index to ENTOMOLOGY.

FIRE, ST ANTHONY'S. See ERYSIPELAS.

FIRE-WORKS. See PYROTECHNY.

FIRE-WORSHIPPERS. See GUEBRES; MAGI; PERSIA; ZEND.

FIRKIN, a measure of capacity, being the fourth part of a barrel. The firkin of ale, which formerly was 8 gallons, by an act of 1803 was made 9 gallons, the same as the barrel of beer, or 9·15340 imperial gallons. The firkin of butter is equal to 56 lb.; that of soap, 64 lb.

FIRLOT, a dry measure used in Scotland, containing 4 pecks or $\frac{1}{4}$ of a boll. The Linlithgow wheat firlot (used also for rye, pease, beans, salt, and grass seeds) is to the imperial standard bushel as 0·998256 to 1. The barley firlot (also used for malt, oats, fruit, and potatoes) is to the imperial standard bushel as 1·4562794 to 1.

FIRMAMENT, in the ancient astronomy, the eighth heaven or sphere, with respect to the seven spheres of the planets which it surrounds. It is supposed to have two motions; a diurnal motion, given to it by the *primum mobile*, from east to west, about the poles of the ecliptic; and another opposite motion, from west to east; which it completes, according to Tycho, in 25,412 years; according to Ptolemy, in 36,000; and according to Copernicus, in 25,800; when the fixed stars return to the same precise points in which they were at the commencement. This period is commonly called the *Platonic* or *great year*.

FIRMAN, a passport issued by the grand vizier in the

name of the sultan to travellers and others. In the East Indies, the term firman is used for a written permission to trade.

FIRMICUS, MATERNUS JULIUS, a Latin writer who flourished under the successors of Constantine. About the year 345 he composed a work entitled *De Erroribus Profanarum Religionum*, which he inscribed to Constantius and Constans, the sons of Constantine, and which is happily still extant, accompanied with the annotations of John Wouver. To Firmicus are also attributed eight books on astronomy, first printed by Aldus Manutius in 1501, and reprinted several times since; but as this work contains nothing relating to the true science of astronomy, and is filled with astrological calculations after the manner of the Babylonians and Egyptians, Baronius doubts whether a good and pious Christian, as Firmicus is represented to have been, could have indulged in such profane and impious speculations. Cave, however, very reasonably supposes that he might have written these books anterior to the date of his conversion from Paganism. Of the treatise on the *Errors of the Profane Religions*, the principal editions subsequent to that of Aldus are, one printed at Strasburg in 1562, another at Heidelberg in 1599, and a third at Paris in 1610, all in 8vo; but afterwards it was conjoined with Minucius Felix, and printed at Amsterdam in 1645, at Leyden in 1652, and again at Leyden by James Gronovius, in 1709, 8vo. It is likewise to be found in the *Bibliotheca Patrum*, and at the end of Cyprian, printed at Paris in 1666. (Dupin; Cave; Moreri; Fabricius, *Bibl. Lat.* and *Bibl. Lat. Med.*) (J. B—E.)

FIRST-FRUITS (*primitiæ*) are frequently mentioned by ancient Christian writers as forming part of the church revenue. In the Church of England, first-fruits are the profits of every spiritual living for the first year, according to the valuation thereof entered in the King's Books. *Tenths* are the tenth of the yearly value of such living, given anciently to the pope throughout all Christendom, but in England, by statute 26th Henry VIII. cap. 3, transferred to the king. By statute 27th Henry VIII. cap. 3, no tenths are payable the first year, as then the first-fruits are due; and, by several statutes in the reign of Queen Anne, benefices under L.50 per annum shall be discharged of the payment of first-fruits and tenths. She also gave up the revenue arising from first-fruits and tenths, and by act 2d and 3d of her reign, cap. 2, established a perpetual fund therefrom, vested in trustees, for the augmentation of poor livings. This is called *Queen Anne's Bounty*, and is further regulated by subsequent statutes. By 3d and 4th William IV., cap. 37, the payment of first-fruits in Ireland is abolished. (See Burn's *Ecclesiastical Law*.)

FISC, (Lat. *fiscus*), in *Civil Law*, the treasury or revenue of a state. Fiscus in its primary sense denoted a basket or hanaper used by the Romans for holding large sums of money, and hence was applied to a money-chest or a purse. Under the emperors the term fiscus came to be applied to the imperial revenue or privy purse, in contradistinction to the *ærarium* or public treasury. Ultimately, when the emperors had concentrated in themselves the whole sovereign power, the word fiscus lost its distinctive character, and was used in the same sense as ærarium under the republic. Various officers were employed in the administration of the fiscus; as procuratores, advocati, patroni, and præfecti. From fisc is derived the word confiscation, which signifies to take the goods of a condemned person and appropriate them to the public treasury.

FISH. See ICHTHYOLOGY.

FISHER, JOHN, Bishop of Rochester, was born at Beverley in Yorkshire, in the year 1459, and educated in the collegiate church of that place. In 1484, he removed to Michael House in Cambridge, of which college he was elected master in the year 1495. Having applied himself to the study of divinity, he took orders; and becoming eminent as a divine, attracted the notice of Margaret, Countess of Richmond, mother of Henry VII., who appointed him her chaplain and confessor. In 1501 he took the degree of doctor in divinity, and the same year was elected chancellor of the university. In the year following he was appointed Lady Margaret's first professor of divinity in Cambridge; and in 1504 he was consecrated Bishop of Rochester. It is generally known that the foundation of the two colleges of Christ-Church and St John's, Cambridge, was owing to Bishop Fisher's influence with the Countess of Richmond; he not only formed the design, but superintended the execution, and was appointed by the statutes visitor for life after the death of Lady Margaret. On the promulgation of Luther's doctrine, the bishop was the first to enter the lists against him. Upon this occasion he exerted all his influence, and is generally supposed to have written the book on account of which Henry VIII. obtained the title of *Defender of the Faith*. Hitherto he had continued in favour with the king; but in 1527, having opposed his divorce from Catherine of Aragon, and denied his supremacy, he was soon exposed to the full brunt of that monarch's resentment. In 1533 the parliament found him guilty of misprision of treason, for concealing certain prophetic speeches of Elizabeth Barton, a fanatical impostor known as the Holy Maid of Kent, relative to the king's death, and condemned him, with five others, to suffer loss of goods and imprisonment during his majesty's pleasure. He was subsequently released upon payment of a fine of L.300.

King Henry having now espoused Anne Boleyn, his obsequious parliament took the oath of allegiance. But in this oath the Bishop of Rochester steadily refused to join, alleging that his conscience had not been convinced that the king's first marriage was against the law of God. For this refusal he was attainted by the parliament of 1534, and committed to the Tower, where he experienced cruel treatment, and would probably have died under his sufferings. It was now that Pope Clement, at once to reward Fisher and spite the king, sent him a cardinal's hat. This kindness, however, only hastened the bishop's ruin. The king, bent on his destruction, sent Rich the solicitor-general, under the pretence of consulting the bishop upon a case of conscience, but really with a design to draw him into a conversation concerning the supremacy. The honest old bishop spoke his mind without suspicion or reserve; and an indictment and conviction of high treason were the consequence. He was beheaded at Tower Hill on the 22d of of June 1535, in the seventy-seventh year of his age. It is impossible to withhold from Fisher, notwithstanding his inflexible enmity to the Reformation, the character of a learned, pious, and honest man. His works attest his learning; his inflexible zeal for his faith, and the readiness with which he died for his creed, plainly prove his honesty as well as his piety.

The Bishop of Rochester was the author of a number of works, of which the following is a list:—*Assertionum Martini Lutheri Confutatio; Defensio Assertionis Henrici Octavi de Septem Sacramentis; Epistola Responsaria Epistolæ Lutheri; Sacerdotii Defensio contra Lutherum; Pro Damnatione Lutheri; De Veritate Corporis et Sanguinis Christi in Eucharistia, adversus Œcompoladium; De Unica Magdalena; Petrum fuisse Romæ;* Several Sermons, amongst which was one preached at the funeral of Henry VII., and another at that of the Countess of Richmond; His opinion of King Henry the Eighth's marriage, in a letter to T. Wolsey, printed at the end of the second volume of Collier's *Ecclesiastical History*. Most of the tracts above mentioned were collected and printed in one volume folio, at Wurtzburg, in 1595. Fisher, as already stated, is supposed to have had a considerable share in the composition of Henry's book entitled *Assertio septem Sacramentorum;* and in the Norfolk library of manuscripts belonging to the Royal Society there is an answer made by him to a book printed at London in 1530, concerning Henry's marriage with Queen Catherine.

FISHERIES.

FISHERIES are of high importance to almost all nations, and peculiarly so to those whose territories are either entirely insular, or partially bounded by the sea. The direct and chief advantage is, of course, to such people as capture, as well as feed upon, the finny tribes; but the curative process, whether for a lengthened period by means of salted pickle, or for a shorter preservation, by the use of ice, now spreads the benefit far inland, into many a distant land which never heard the surging of the sea. As the great nursery for sailors, and the producer of habitual hardihood, and a fearlessness of winds and waves, our British fisheries are altogether invaluable—that is, they greatly transcend all those merely pecuniary advantages, however great, which can be calculated and made manifest by statistical documents of whatever kind. Sir Henry Wotton was of opinion that there was something in the capture of fish, even when pursued as a trade, which tended to improve the moral, if not the intellectual character of those engaged in it, and to bring them up for the most part, however unlettered, as a patient, simple, humane, and hardy race—not insensible, in the midst of stormy days and nights of darkness, to the sublime feeling of dependence on a higher power, and with a preparedness to acknowledge and obey the divine will. We are told from the highest source that they that "do business in the great waters, these see the works of the Lord, and his wonders in the deep." How far they are permanently impressed thereby, to their own advantage, we are not prepared to say; but the difficulties which beset their adventurous calling, and the early period at which their professional life commences, and becomes of value, make it all the more incumbent upon others to attend both to the educational and spiritual interests of a peculiar people to whose hardihood we owe so much. "Men-of-war, and merchantmen," writes Sir Robert l'Estrange, "consume men and breed none; the collier brings up now and then an apprentice, but still spends more than he makes; the only other and common nursery of seamen is this fishery (that of herrings), where every buss brings up, it may be, six, eight, or ten new men every year, so that our fishery is just as necessary to our navigation as to our safety and well-being. And it is well observed that all the princes are stronger or weaker at sea, according to the measures of their fisheries." Lacepede regards the herring as "une de ces productions dont l'emploi décide de la destinée des empires;" and the great Cuvier has recorded that the government of all nations possessed of any sea-coast where that fish is known, has given special attention and encouragement to its capture—regarding such occupation as the finest nursery for the formation of robust men, intrepid sailors, and skilful navigators, and so of the highest consequence towards the ensuring of maritime greatness. This remark, it has been well observed, coming from the native of a country with a limited sea-coast, has irresistible force when applied to islands like Great Britain and Ireland, possessed of immense colonies in every quarter of the earth, "on whose dominions the sun never sets," and thus requiring unceasing supplies of seamen for a naval and commercial marine of greater size and power than any known in ancient or modern times. Let these authorities suffice as an introductory exordium.

It does not matter much which department of our subject we begin with. Let us take up the fresh waters first, and in these, we need scarcely say, the most important species we can encounter is the salmon—*Salmo salar* of naturalists.

As regards the historical view, we may state, that the ancients knew little of trout, and nothing of salmon, which are the glory of the group. If observed in any way by the Greeks, the latter would not have escaped the notice of the lynx-eyed Aristotle. The salmon is not a Mediterranean species, and so does not occur in such of the rivers of France as debouche into that inland sea. It is cursorily alluded to by Pliny, who of course does not describe it as an Italian fish, but as native to certain rivers in Aquitaine. Ausonius is the first Latin poet who mentions the salmon under its present title:—

> Nec te puniceo rutilantem viscere, Salmo,
> Transierim:

And in another place he writes of,

> Purpureisque salar stellatus tergora guttis.[1]

We have here to do, however, with the natural and commercial rather than the classical history of the finny tribes, and so shall proceed to consider them as they are known to us in this our day.

The parent salmon show themselves at the mouths of rivers, and endeavour to ascend the same during almost every month throughout the year, although the process of spawning does not usually take place till winter, that is, from the beginning of October to the close of January—November and December being the principal months in the majority of rivers. They generally delay their ascent in any great number till the streams are somewhat swollen by heavy rains, although in the lower portions of the larger rivers there may be a more frequent *run*. When the *fresh* or flood has fairly intermingled with the estuaries the upward movement is often rapid and multitudinous, especially if there has previously occurred a long continued course of dry weather.[2] This marvellous instinctive desire to return to their native streams is irrepressible. It induces them to stem the current of surging rivers, to force their perilous way into many a "hell of waters," to ascend precipitous falls, and pass over weirs and similar obstacles of human intervention, which no other or less pervading power could either vanquish or evade.

The spawn is deposited in troughs made by the parents to a considerable depth in the gravel, and is afterwards covered over in like manner. Both sexes are necessarily present, but observers differ as to the share assumed by the male in the removal of the gravel, and whether the female, supposing that she is the chief builder, makes most use of her head or tail.[3] According to Mr Andrew Young, the fish al-

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[1] An amusing and instructive volume on the literary history of fish has been recently published. See *Prose Halieutics, or Ancient and Modern Fish Tattle.* By the Rev. C. D. Badham, M.D., London, 1854.

[2] The greatest haul of salmon that we know of on record, is that which befel the fishermen of Thurso, more than a century ago. At a single sweep one day in July the enormous number of 2500 were secured. A large net was used sweepingly, from the cruives of the river down to the lower end of the pool, being taken by 18 or 20 men, who kept the ground-rope low with long poles. The fish (including, we doubt not, grilse, as well as adult salmon) were afterwards taken ashore in a smaller net.

[3] Mr Shaw is of opinion that the labour of the trenches devolves upon the female, and that the excavation is performed chiefly by a flapping movement of the tail, which is obviously an engine of great force in fishes. The same observation, or rather inference, had been made (unknown to Mr Shaw) by Mr Potts, in relation to the Tweed salmon, as long since quoted by Pennant in his *British Zoology*. That gentleman regarded the tail as the instrument by which the gravel is displaced, in consequence of his having so frequently found that part rubbed or abraded as it were by violent action. Mr Fraser of Dochnalurg (to whom we owe a pamphlet on the salmon

Spawning of salmon.

ways approach the spawning bed in pairs. The places usually selected are rippling fords or shallows of not more than two or three feet in depth, sometimes less, where the gravel is clean and not too heavy, and the water clear and in constant flow. Their first object is to dig a trench, a work of some labour, as they prefer a somewhat firm or compacted bed, less liable to shift than one of looser gravel. They begin the operation by falling down a few yards below the chosen spot, and then tilting up against it with their heads, thus by repeated efforts displacing a portion of the gravel, and so forming the commencement of their first parallel. The excavation varies in depth from nine to eighteen inches, according to the nature and consistence of the material, or the requirements of the situation, of which, no doubt, the fishes themselves are the best judges. When the trench is regarded as of sufficient depth, the female deposits in it the ripest portion of her ova, and the male sheds his milt among them. A careful observer may perceive both products falling into, and settling at the bottom, and as soon as all is right in that respect, another tilting takes place against the gravel, the effect of which is to continue the trench, while the loosened materials are aided in their movement by the current, and falling into the previous hollow, help to cover up the ova. This higher portion in like manner receives its share of ova and milt, and so the work proceeds till it is finished. In this labour several days may be consumed. The parent fish then fall down the river into the first deep they come to, and there they abide for a time for repose and restoration. They are usually much discoloured at this period, the females dark and inky, the males streaked and stained with rusty red, and the under jaw very obtrusive, and upturned into a snout or *kip*. They then gradually make their way through stream and pool towards the tideway, and by this time, although flabby and flavourless, their stains have been in a great measure washed away, and the silvery lustre re-assumed. Hence the Scotch expression of "a weel-mended kelt," signifying a fish in this half-recovered but still impoverished condition, and which the deluded (and deluding) angler not seldom seeks to glorify by the name of salmon. The majority of early spring fish taken by the rod are kelts, and many a man would much rather never fish at all than kill a score of them. In general the males are the first to leave the river, many of the females abiding there till March or even May, especially in dry weather when they cannot pass in safety downwards from pool to pool. It is believed that they no sooner reach the salubrious sea than their muscular firmness, fine flavour, and brilliant lustre are restored. They then increase rapidly, and after a few months return to the rivers as beautiful, and far bigger than before—the soonest down being probably the earliest to re-appear. So much for the old fish.[1] Let us now inquire after the spawn.

Early state of salmon.

The period of hatching of the ova varies with the rigour of the season and the time of deposition. If spawned early the young will burst their cerements in from 90 to 100 days, while such as are laid in December may require 140 days before they break the shell. There are also intermediate periods corresponding to the temperature of the place or season. The fry are at first very slender, but extremely agile little things, about three-quarters of an inch in length, with none of the fins distinctly developed save the pectoral, and bearing beneath the body a comparatively large bag of a beautiful transparent red, like a pale-coloured currant, attached to the abdomen, and affording the young fish an ample supply of nourishment for several weeks. This is the yelk or vitelline portion of the egg. They continue for a length of time to keep themselves in a great measure concealed from public view among the stones and gravel, are quick-sighted as well as active, and have the instinct of self-preservation so strongly implanted from the first, that the waving of the smallest wand, or the passing shadow of an outstretched arm, is sufficient to cause their instantaneous disappearance among the multitudinous little caves and arched recesses with which their shingly bed abounds. While quiescent, they seem to be almost in a helpless state, and are not only borne down but overbalanced by the pea-like body attached to the abdomen, and which, gravitating in accordance with its own constitution, throws the fry over on their sides. In this position they so resemble the subjacent soil, that though a score of them may be lying in the impressed mark of a horse's hoof, they can only be discovered by the brilliant colour of their "provision bag." As soon, however, as they are set in motion they assume their natural position, and swim away with the bag beneath them, and with great facility. They continue in this independent and inconspicuous state for several weeks, being nourished all the time, so far as has been ascertained, by the gradually absorbed remains of the vitelline portion of the egg, which constitutes the bag just mentioned. The period of absorption seems to vary with

isheries) describes the action as resembling that of a hen shuffling with her wings in earth or sand. The spawners, he alleges, lie on their sides, and, while making the furrows, remove the gravel by a quick jerk and curvature of their bodies, but principally by the fins and tail. At this period, as he further informs us, they are always accompanied by a horde of trouts, which are very alert in picking up the ova as they drop, and the male spawner is every now and then seen chasing them away.

The following are Mr Shaw's most recent observations, regarding the same process as performed by the common river trout, *Salmo fario*, and which he regards as confirming by analogy the proceedings of the salmon. "I have had many excellent opportunities this last autumn of observing the interesting process of trouts depositing their spawn in a small stream which runs into a well-stocked loch in this neighbourhood. The stream in which they were spawning was not more than six inches deep, and the fishes were as distinctly seen as if in a glass on the drawing-room table. By creeping up to them on hands and knees under the shade of a dark bush, I was able to watch them for hours unseen, and so near that I could have put my hands on them with ease. The male, as I have already often stated, took no part in the process of digging, contenting himself by keeping nearly parallel with the female, and close to the bottom of the spawning bed when at rest. The female, while in the act of removing the materials, always had her head a few inches above the level of the gravel at the bottom, while her tail was at the same time working actively on the gravel immediately under it, and the small pebbles could be distinctly seen in motion at the same time. I do not mean to say that the female salmon removes the gravel with her tail, as if actually with a spade, but that by the broad surface of the caudal extremity acting vertically on the water near the bottom, that water readily removes the gravel below, which is always loose and shingly on spawning streams. In short, the fact of the salmon removing the gravel by the action of the tail can no longer admit of a doubt."—MS., 16th March 1855.

[1] We have reason to believe that salmon suffer by a *forced* retention in the sea, as well as from a too prolonged sojourn in the fresh waters. A case of this kind is supposed to have occurred at the mouth of the Grimsta, in the island of Lewis, in August 1852. During a continuance of dry weather at that time, the fish were found dying in great numbers in the salt water, just off the river's mouth; and this was attributed to their inability from want of water to ascend the stream. The immediate ailment, whatever might be its cause, seemed to be a softening and slight discoloration of a part of the upper portion of the skull, with an appearance of sinking or indentation in its centre: a specimen was kindly transmitted to us by Mr Francis W. Wilson for examination. We have preserved the skull. Another cranium of a salmon in our collection is slightly disorganized from a different cause. While a friend was playing a kelt one morning in early spring, near Cardrona, on the Tweed, our notice was attracted by a bright red light (the signal of danger) which the fish seemed to bear aloft upon its forehead. When stretched upon the dewy turf, we found on closer examination that there was a large fresh wound, which seemed nearly to have fractured the skull, laying it bare for about a couple of inches. It had no doubt been quite recently inflicted by a violent though misdirected blow from a leister, and yet the fish had not been so sickened thereby as to lose its appetite for artificial flies, one of which, though a frail thing compared with a poacher's trident, had just caused its capture.

Early state of salmon.

the temperature and other circumstances, and admits of a range of from 27 to 50 days. While lessening, it assimilates somewhat in colour to the rest of the body, and finally disappears. That animalcular food is also, towards the conclusion of this period, obtained through the mouth, there need be no doubt. It is not, however, till they are nearly two months old that they can be perceived as in pursuit of prey.

The growth of salmon fry is by no means rapid during their first summer. For several months they require to be narrowly looked for among the shingle (into which they are so fond of darting) before they can be seen. But as at this period, and throughout the season, our rivers are amply stocked with small fry of the same kind, but much more conspicuous from their larger size, and less timid habits, it becomes evident that we have two broods in hand, the smaller of which are the product of the immediately preceding spring, the larger that of the spring of a year and some months passed and gone. Both broods taken together constitute what are termed *parr*, and the larger set are those which afford such frequent though improvident amusement to the more juvenile class of anglers. Now the great constitutional change which converts an old parr into a young salmon (commonly called a smolt) takes place in spring, and consists mainly in the following alterations. The black spots upon the opercles or gill-covers disappear; the pale-coloured pectoral fins become deeply suffused by an inky hue at their extremities; the broad and conspicuous bars or blotches on the sides are effaced or rendered invisible, and the prevailing hues of dusky brown and yellowish white are converted into a dark bluish black upon the upper parts, and into a brilliant silvery white upon the lower sides and abdomen. The old opinion was that salmon fry grew to the length of six or seven inches in as many weeks. What led to this long-continued error was the rapidity with which the mature parr assumed the aspect of the acknowledged smolt. Superficial observers, and almost all were so on this particular point at the time referred to, taking cognisance, first, of the hatching of the ova in early spring, and secondly, of the sudden appearance and seaward migration of smolts so soon afterwards, erroneously imagined these two facts to take place in immediate or speedy succession and connection, whereas in truth they had no more to do with each other than an infant in the nurse's arms has to do with any active lad who may be setting forth to push his fortunes in a far country. It is now known and universally admitted that the parr remains at least an entire year in the fresh water streams before it becomes a smolt, so that the latter is necessarily not of the same generation as those hatched during the spring, in which it seeks the sea.

We owe the demonstration of this important fact, which had been previously nothing more than surmised, to Mr John Shaw of Drumlanrig. The essential value of Mr Shaw's discovery consists in his having proved the identity of that abundant little fish commonly called parr, with the young or earliest condition of the salmon. He also showed its long continuance in fresh water, its after conversion into the smolt, and the consequent absurdity of supposing that the latter went off to the sea in a few weeks after it was hatched. The importance and originality of his observations are independent of the fact—whether a certain portion of parr require one or two years in fresh water.

That excellent observer had been long convinced, in opposition to the prevailing sentiments upon the subject, that the small and most abundant, though by no means well-known fish, commonly called *parr*, was the young or natural produce of the salmon, and that all previously recorded attempts to trace the true history of the latter noble species in its early state were delusive and without foundation. So far back as the 11th of July 1833, he captured a few score of these small fishes, and placed them in a commodious pond, supplied by a wholesome streamlet, where they were as happy as the day was long. They throve and prospered to a wish, and in the ensuing month of April began to assume a somewhat different aspect, and in the earlier part of May were converted into what are usually called *salmon smolts*—that is, they lost the perpendicular or transverse bars, became of a fine deep blue upon the back. the sides and under portions being as lustrous as silver, and the scales deciduous, or coming easily off upon the hand In March 1835 he renewed the experiment, by taking from the river about a dozen parr of a large size—that is, about six inches long. They at this time bore the transverse blotches, and all the other obvious characteristics of the so-called parr. He transferred them to his pond, and by the end of April of the same year they too assumed the livery of the salmon fry, the dark bars becoming overlaid by silvery scales. It is clear that if *all parr* were converted into smolts when they were only about a year old, then so soon as the smolting process and the immediately ensuing migration to the sea have taken place, none would remain in the river except the small and inconspicuous fry of a few weeks old, already referred to as the darkling denizens of the shingle. But as this is not the case—as June, July, August, and so on, have from the first their shapely well-grown parr, besides those more minute and unobtrusive relatives amid the stones below, we can draw no other conclusion than that which Mr Shaw has drawn—to wit, that all the larger summer and autumnal parr are in truth young salmon advancing into their second year, and not ripe for the smolting process till the ensuing spring, by which time of course they must be two years old.

Identity of parr and smolts.

Prior to this ingenious identification of the parr and salmon smolt, and the demonstration of the lengthened sojourn of the latter in fresh water, the former was unavoidably regarded as constituting in its proper person a distinct and permanent species—that is, a continuous and inconvertible parr. What might be its early history no one knew, and as no female parr with matured roe had been ever met with, a considerate observer must have been sorely perplexed when he thought of its maternity. Its predecessors and posterity were alike a mystery—the only ascertainable fact being a truism, and fortunately self-evident, that the existing race existed. Mr Shaw, while making in the month of May 1834 a minute examination of some streams in which salmon were known to have spawned during the preceding winter, found there in vast numbers a very minute but extremely agile fish, which, from its position, he naturally concluded to be the young parr or actual samlet of the season. To test the truth of this opinion he scooped up a few score, the individuals not measuring more than an inch long. He placed them in his ponds, where they throve well, although after the lapse of an entire year they were only three inches and a half in length. At this time (May 1835) they entirely corresponded to the small or medium-sized parr to be seen in the natural streams of the river, and neither the free nor the captive brood of these dimensions exhibited any tendency to assume the silvery aspect of the smolt. Our observer, however, felt satisfied, from the result of his former tentative experiments on the parr, that they would ultimately assume that aspect; so he allowed them to bide their time, and accordingly in May 1836 they were transmuted into smolts or salmon fry. They then measured six inches and a half in length, the colour of the dorsal region being a fine bluish-black, the sides and abdomen silvery white, the dorsal, caudal, and especially the pectoral fins tinged with black. The smolts in the river were at this time descending seawards,—no difference could be discovered between these and their brethren in captivity,—the latter were *known* to have completed their second year, and so Mr Shaw very naturally asks,

Age of smolts.

"Is it likely that those in the river were only a few weeks old?"

It thus appears that the fry of salmon may be seen by any careful observer, in such rivers as produce them, early in the month of April, but so young and weak, in consequence of their recent emergence from the spawning beds, as to be unable to struggle with the current. They therefore betake themselves to the gentler eddies and other quiet places during spring and the earlier part of summer; but as they gain an increase of size and strength they begin to scatter themselves more independently over all the shallower portions of the river, especially where the bottom is composed of fine gravel. They thus continue comparatively unobserved throughout the whole of their first summer, during which they seldom take the angler's fly. But no sooner do the two-year-olds, according to Mr Shaw's theory, disappear as smolts in spring than these smaller fishes, now entering upon their second season, become bolder and more apparent, and then constitute, and continue for another year to constitute, the parr of anglers and of other observers. Their shy and shingle-seeking habits during the early months of their career so screen them from ordinary observation as to have induced the erroneous belief already mentioned, that the silvery smolts were the actual produce of the very season in which these are first observable, and were only a few weeks old—the fact seeming to be, that prior to their seaward emigration they had dwelt for a couple of years in "rivers of water." Now that we know this strange history, it seems still stranger that in the days of our ignorance no angler should have troubled himself to inquire what became of the older generation of parr—that is, of the comparatively large individuals which may be captured late in autumn and in early spring, but scarcely one of which can be detected after the departure of the smolts into the sea. If the two were not identical, how did it happen that one so constantly disappeared simultaneously with the other? But their identity has been demonstrated, and the disappearance of these full-grown parr is caused by their conversion into smolts.

In giving Mr Shaw's view of the comparatively slow progress of the development of parr, and stating our own belief, for the reasons assigned, in the general truth of the *biennial* theory, as it may be called, we must not omit to state that several excellent, experienced, and trustworthy observers have come to another conclusion, and, while admitting the value and importance of Mr Shaw's discoveries, maintain that a single completed year suffices to convert a parr into a smolt. It may be here mentioned, that in the course of Mr Shaw's experiments, it happened each time that some of his captive specimens *smolted* when they were little more than a year old; and this, say some, instead of being an exceptional occurrence, was rather an indication of what would have happened to the whole, had they been in their natural and unconstrained condition in the open river, instead of being shut up in a pond. We think Mr Shaw has fenced the matter well, by showing that a similar change was very obviously going on in the river among the larger and older parr, but not among the younger and smaller; and his opponents can in no way explain or account for (consistently with their *annual* theory) the continuance of so many obviously year-old parr in the river for such a continuous length of time after the departure of the smolts in spring. At the same time it is proper to consider the facts on both sides. Mr Andrew Young of Invershin, who has well availed himself of the amplest opportunities for experimental observation, informs us that the fry (or parr) of his ponds became smolts at the end of the first year, and that frequent trials brought forth the same result. We have every confidence in Mr Young's statements, and therefore know not how to reconcile the opposing facts. This much, however, consists with our own knowledge, that the river Shin, by the banks of which Mr Young's experiments were made, abounds *all summer* with well-grown parr in their second season—that is, we find them there, as elsewhere, for many a month after the smolts have taken their departure to the sea. These specimens we have not seldom had it in our power to exhibit to Mr Young himself. We observe that Mr Ramsbottom has also recently followed the same course. He observes, in a note addressed to us from the banks of the Shin, and dated 12th May 1855, "I killed for him (Mr Young) in his own river, with a small midge fly, both the year-old parr and the two-year-old smolt, and could kill a hundred of both ages in one day if he required them." And we continue to find them in, and to have them transmitted from, numerous other salmon rivers. They are now (August 1855) plentiful in the Tay, although the smolts are long since gone. It will be seen then that Mr Young's opponents may also on their part assume that his cases might be deemed exceptional, by reason of being pond-bred, and that they were thereby rendered more mature—just as he alleges that Mr Shaw's were made exceptional by the same means though in the opposite direction, being retarded rather than hastened in their great change.[1] The truth is that perfect accuracy of observation is by no means easy, even with the best intentions. Of this we have a good example in the reports published from time to time regarding the parr brought up in the great and successful breeding pond at Stormontfield, a few miles above Perth. The ova were deposited after subjection to the artificial or mechanical process of impregnation in the winter of 1853, and were hatched in the spring of 1854. Though necessarily of very small dimensions during the first summer, they throve well, and were reported on as being not only a healthy colony of young fish, but as by the month of October attaining "nearly the size and getting the silvery appearance of smolts." This silvery appearance had never been seen or heard of before, as manifested by any parr of salmon born, when it was scarcely seven months old. Nothing of the kind was observable in any of the natural streams of Scotland. So also, early in the ensuing month of April a party of gentlemen from Perth visited the ponds, and brought back with them "a smolt completely covered with silvery scales, and fully as forward as any at present in the river. The fish was caught with the rod and a small fly, and was the only one that rose, and may be considered as *a fair average specimen of what the pond contains.* In shape it is faultless, being finely grown, and the parr marks obliterated by the newly-acquired scales. So this long-disputed question has at length been settled, and Mr Andrew Young's, of Bonar Bridge, statement has been proved the true one." If by this it was meant that *all parr* assume the aspect of smolts, and become fit for their seaward migration when little more than a year old, the

[1] In regard to these supposed exceptional cases, Mr Shaw, in a recent letter, observes as follows:—"The circumstance of some individuals assuming the smolt condition at the end of twelve months, in each brood, does not in the least degree invalidate my statement that *by far the larger portion of them do not.* The smolts of the Nith have now all departed for the sea, and consequently the truth of what I have so often stated is at this moment very clear, there being no other parr to be caught with the fly but the *one-year-olds,* measuring from 3½ to 4 inches long, while the young of this year measure about 1¼ inches. There is one very important fact which has escaped the notice of my opponents, that is, the characteristic condition of the male autumnal parr, in respect to the *maturity of its milt,* not one of the persons connected with the Perth ponds having ever asserted that even a single sample of their brood had been yet found in that condition. Now it is notorious to every one that parr are found in thousands in that state every autumn, in every salmon river, and that they are then capable of reproduction."—MS., June 11, 1855.

Age of smolts.

conclusion is certainly erroneous, and can easily be disproved. We believe there is some risk that, when the matter under discussion comes to bear upon the commercial or industrial branches of the subject, the wish may be the father of the thought. As all parr in spring, just like the feathered tribes during the same season, become beautified by a great freshening in their general aspect—an increase of blue and silver, a decrease of brown and yellow —they are thus apt to be designated as smolts, when they are really far from that condition. The term, too, is very vaguely applied. All parr are smolts in the sense that they are young salmon, but the title, to avoid confusion, ought to be restricted to that brief period of the spring in which these small fishes have changed their barred and spotted livery into a more contrasted coating of bluish-black and shining silver, and are at the same time under the influence of the migratory movement to the sea. Of course this universal conversion at a year old, if the correct view, would be by much the more advantageous one for the artificial breeder, in so far as, in the rearing of his young fish, he would save a year's care and keeping; and where there is only a single artificial pond, that pond might be emptied of its contents each season, and the newly-hatched fry let down into it from the spawning-troughs above, without any risk of their being swallowed alive by their stronger if not more carnivorous connections.

Having our own prepossessions in favour of Mr Shaw's views, although we trust without undue bias from any spirit of partizanship, we felt anxious to satisfy ourselves by personal inspection regarding facts which did certainly not accord with our own experience. So in company with Mr Shaw, we availed ourselves of an invitation to meet the parties principally concerned at Stormontfield on the 2d of May 1855. This was more than six months after the time of these fry having been first reported as assuming the smolt aspect, and a few weeks after that of their being for the second time so reported. We shall now state what occurred. The most ample opportunity and every convenience were afforded us for a satisfactory examination of the contents of the pond, which is excellently well constructed for the purpose in view. We saw many thousands of these imprisoned parr with sufficient distinctness to receive a correct impression of their actual state; and we moreover netted a sufficient number to serve as representatives for a closer and more minute examination. Although these fish were by that time at least about thirteen months old, and were in fine condition, *there was not a single smolt among them.* They corresponded entirely to the year-old parr, which we took for comparison from the adjoining river Tay. The only example of a smolt exhibited to the meeting, in the course of a careful and prolonged investigation, was one caught by a gentleman while angling *in the river*, and who had tried his skill for a corresponding specimen in vain within the precincts of the pond. He brought it up to us without delay, and when placed in a vessel beside the pond-bred parr, its greater size, more salmon-like shape, and spotless silvery lustre, made its difference of aspect obvious to all. The meeting, therefore, came to the unanimous and unavoidable conclusion that the multitudinous inhabitants of the pond were still, without exception, parr; and in this opinion Mr Shaw and the writer of this article cordially concurred. Lord Mansfield and others pressed for their detention for another year, and their continued captivity was, as we understood, determined on.

Age of smolts.

We here record only to the extent that we have personally ascertained and seen. But we doubt not that fishes, like flies and flowers, are under the influence of temperature, and as the preceding winter and spring were seasons of great severity, an unusual retardation may have taken place. Mr Robert Buist of Perth, to whom we have been indebted for much valuable information on these matters, informs us that in the course of a week or two after our visit a marked change took place, and that a great number of smolts, in the genuine silvery state, began to show themselves, while many others exhibited unmistakable symptoms of a corresponding change. It is not alleged that this conversion was complete or universal, but we can entertain no doubt, from the evidence laid before us, that at least a transformation of some kind occurred. Samples have been sent us which, though somewhat discoloured by the medium in which they were preserved, seem to have lost the parr markings, and assumed the silvery aspect. We do not know in what proportion this took place, but we may presume, from the ascertained fact of so many midsummer parr of good size being still found in the Tay, that these would have continued and been recognised as likewise in the ponds, if not set at liberty with their more brilliant brethren. The determination as to further detention was, however, altered, the sluice was lowered, and the fry allowed their freedom.[1] We have no doubt they will make a good use of it, and that such as prefer a second season in fresh water will rejoice in the pleasant reaches of the Tay. Meanwhile the thing to guard against on the one side is the assertion that *no parr* becomes a smolt till the termination of its second year, and on the other, that *all parr* become smolts soon after the conclusion of their first twelvemonth. If it takes some time to prove the former statement, there is scarcely a day in the year in which we cannot disprove the latter.

We have ourselves repeatedly demonstrated, by observations of the easiest and most simple kind, that there are three distinct stages or different broods of parr, that is, young salmon, in our rivers during early spring. We have, *first*, those which, recently excluded from the ova, are still, if not invisible to common eyes, so small and inconspicuous as to be unobservable till notice is directed towards them. We have, *secondly*, those which are just completing their first year, and which, owing to the continued cold of the preceding winter, and consequent deficiency of insect food, are very little larger than they were at the end of the preceding month of October—seldom measuring more than three inches. They increase, however, rapidly as the summer advances, and then form the obvious and admitted parr which stock our rivers. We have, *thirdly*, for a short time, along with the two preceding broods, those large and (so far as concerns the males) sexually developed parr, which have completed their second year, and are characterized by their brightness as well as size. In the months of April and May these lose the parr appearance, are converted into silvery smolts, and immediately take their departure downwards to the sea. After this all those parr that are only a year old, or a little upwards, are found in the *rivers* (whatever they may be in the ponds) apparently as numerous as ever.[2]

[1] "The rapid growth of the fry, the large proportion which immediately progressed into indisputable smolts, and the striking evidences which the larger inhabitants of the ponds themselves clearly manifested that the time of migration had really arrived, led to the wiser resolution of the committee, that the more advanced and matured of their charge should be allowed to follow the dictates of their nature." *Perthshire Courier*, 26th July 1855.

[2] Mr Ramsbottom of Clitheroe, who has had great experience as an angler, and has of late been largely employed in conducting the process of artificial impregnation, of which he has watched the results, records his opinion as follows:—"Artificial propagation has not only proved and settled this great question, but it has taught me to see it in thirty-three different rivers in Great Britain and Ireland, in which I have angled with the rod. You must understand that the parr or salmon fry, towards the close of the second year, has to undergo a change which it cannot attain to in its first. Every male fry or parr belonging to the salmon gets a developed milt at the close of its second year, and parts with it in winter in the spawning bed of the adult salmon. It then becomes a smolt in spring, just

Constitution of the male parr.

We may now notice some anomalous and very peculiar circumstances connected with the natural constitution of the parr, which some have recently supposed to throw great light upon this vexed question, if they do not reconcile its apparent contradictions. It is well known to every experienced observer that a va-t proportion of the larger parr so frequently referred to are males; that is, that so far as any sexual characteristics are manifested, it is the milters alone which show such signs. The male parr is sexually mature when sixteen or eighteen months old (of course, if converted into smolts when a year old, they could have no existence at such an age), while the female, even in her most advanced state, has the ovaries so slightly developed, and their contents so extremely minute, that they generally require the aid of a lens to detect the granular form of the incipient ova. (Exceptional cases occur, though rarely. Mr J. C. Heysham of Carlisle took a female parr in March with the ova largely developed. Other instances are recorded by Mr Yarrell, *British Fishes*, vol. ii., p. 48). The observation is as old as the joint work of Ray and Willoughby (*De Historia Piscium*, Oxon., 1686). In this early, though admirable volume, we have first a description of the salmon, and then of a small fish resembling the young river trout, and which these authors properly regard as identical with the *branlin* of the north of England; in other words, the parr. The passage is headed—"Salmulus, Herefordiæ samlet dictus, Branlino D. Johnson inferiore descripto, ut nobis videtur, idem." "Hujus generis," he adds, "omnes (quod mirum) *mares esse aiunt*. Truttæ persimilis est, at certamen specie differe videtur." We have, then, an enumeration of "Pisces fluviatiles et anadromi è genere truttaceo in Septentrionalibus Angliæ observati à D. Johnson," in the course of which the branlin above named is described in more detail, and some very remarkable peculiarities in its sexual character and constitution are particularized:—"*Branlinus*, nonnullis *fingerins*, *i.e.* digitales, dicti, quia notas seu areolas transversas nigricantes quinque aut sex, veluti tot digitorum vestigia impressa, in lateribus obtinent, cum macula rubra in unaquaque areola. Caudæ sunt forcipatæ, salmonum ritu; *quodque mirum est, omnes mares.* Cum salmonibus, procreandi causa, misceri eos mihi persuasum est. Quum primum enim salmo ovorum editorum congeriem, seu acervum, malis dicere, relinquit, branlinus mox ei incumbit, ovaque (ut verisimile est) spermate suo irrigat et fœcundat; nec alibi unquam inveniuntur *branlini* quam iis in locis quæ salmonis frequentant."

It need scarcely be noted that the preceding observations were not likely to be known to Mr Shaw. But, guided by what he had actually seen occurring in the river beds, he took, in the month of January 1837, a female salmon, weighing fourteen pounds, from her natural spawning place, from whence also he secured a male parr, weighing one and a half ounce. With the milt of the latter he fecundated the ova of the former, and placing the spawn in the small streamlet which acts as the feeder of one of his ponds, he carefully observed its growth, as he had previously that of the salmon spawn impregnated in the ordinary way, and found both the hatching and subsequent growth to correspond in all points with the usual ongoings of nature. This remarkable experiment was repeated with the same results during the winter of 1838, and the parr (taken from the river) which had been used as males were kept alive till spring, when they assumed the migratory dress of young salmon. He then tried a corresponding experiment by impregnating the ova of three adult salmon taken from the river with the milt of three parr bred in confinement, and the results in these cases were the same, both as regards hatching and final growth. The subjects of these trials are now preserved in the museum of the Royal Society of Edinburgh. As these male parr are not mature till well advanced into their second year, and some months after all smolting has ceased, it is clear that, so far as they are concerned, the *biennial* theory is the one that suits them, and which they confirm.

Alleged difference in the habits of male and female.

We have already said that certain observations had recently been made which some regarded as reconciling the opposing views. We have seen them in the *Scotsman* newspaper (of June 6, 1855), from which we make the following extract. The writer begins by stating his belief that, as not unfrequently happens in such discussions, while both parties are in the right, both are also in the wrong. He knows, from observations continued during several years under peculiarly favourable circumstances, that about one-half of the salmon fry produced descend to the sea when one year, and the other half when two years old.

"This important and certainly very singular fact I learned under the following circumstances:—The river Wharfe in Yorkshire was, from forty to fifty years ago, and is yet, for anything I know to the contrary, a sort of experimental breeding-stream for salmon, where the progress and appearance of the young fry may be observed with great accuracy and certainty. Owing to the existence of a very lofty and difficult weir at Wetherby, the salmon can only pass beyond that place when there is a peculiarly favourable concurrence of high floods in autumn; and the consequence has been, that for many years past the fish have succeeded in making their way as far as Harewood and Otley about, on an average, once in five or six years, and the fishermen are therefore enabled to observe what follows the spawning of a few salmon in any particular year without being puzzled and misled by having fry of different years mixed together; from which fact nearly all the uncertainty that has attended this subject in former years has unquestionably arisen. They are thus enabled to state beforehand what sort of salmon fry will be found in the first, second, and third years after spawning has taken place.

"During the first summer they find in the river small parr, which in autumn begin freely to rise at the fly, and are then of two perfectly distinct sizes. In the following spring, generally in April, but varying according to the temperature, the larger of these two species of parr assume the silvery appearance of the smolt, and descend to the sea, leaving behind them all those which were of the second size, and which still retain in perfection the peculiar marking of the parr. These grow considerably during the summer, and in autumn afford, when numerous, sport to the

as it enters on its third year. This is also the case with both the sea trout and the brown trout, nature having so ordered it that the male fish is ready for spawning twelve months before the female—a great secret this, which has puzzled all the writers on the subject, and of which they are ignorant to this day. Every female, on the contrary, deposits her first ova at the close of the third year. You will find your young fish very little larger this month (March) than they were in October last, as neither trout nor salmon grow in winter. Some people will tell you that the young fish are retarded by being kept in the pond during winter. Ask them just to prove it. But whether the salmon fry be retarded in its growth or not, whether it be lean for want of food, or through abundance be grown to double its natural size, it will in either case become a smolt as it enters on its third year."—MS., 5th March 1855.

We may here add that Mr Ramsbottom is very sanguine of an extremely advantageous result from the new process which now prevails, and in the manipulation of which he has been singularly successful. This process consists in capturing (with net) a male and female salmon, both about to spawn, and mingling the milt of the one with the ova of the other. These impregnated ova are then deposited in gravel beds made in imitation of the natural spawning places, a current of pure water being kept constantly in movement over and among them. The chief advantage of the artificial process is its certainty. The natural spawning places are too often torn up, and their contents carried away and so destroyed by sudden floods; but in those artificially constructed, the supply of water is moderated by a sluice, and thus no injury from its violent action can occur.

Alleged difference in the habits of male and female.

juvenile angler. I have caught hundreds of them in and about the month of October, and have almost invariably found them to contain milt, showing that they were male fish. The necessary inference from this fact is, of course, that those who had descended to the sea during the previous spring were females. These male fish, during the following spring, generally about the beginning of March, assume the blue and silvery appearance of the smolt, the change being evidently due to the greater opacity of the scales, which no longer permit the spots and markings of the parr to be visible through them. Another change also takes place in these fish about the same time; their pectoral fins assume a deep blue colour. This change, if I recollect rightly, is not observable in the females when they descend to the sea at the end of the first year.

"When the males have descended the rivers, no salmon fry of any kind are left in the Wharfe, and none will be found there probably for two or three years, when another arrival of the parent fish will cause a repetition of the facts which I have just detailed.

"It was by a careful observation of these facts that the fishermen on the Wharfe were, fifty years ago or more, well acquainted with the natural history of the salmon, when the wildest absurdities were almost universally maintained respecting it in other quarters. It was generally asserted and believed that the smolts which filled the river in the spring were the produce of the spawn deposited during the preceding winter, although that spawn was at the very time still lying in the spawning beds; and Mr Yarrell, in the first edition of his excellent work on British Fishes, was so perplexed by what he had heard on the subject, as to make in two different pages of his book the two utterly inconsistent statements to which I have just referred.

"I may here remark—lest it should be supposed that the two different classes of smolts to which I have just referred were, or might be, the produce of different fish of the salmon kind—that no salmon-mort, sea-trout, or bull-trout, was ever, so far as I know, seen in the Wharfe above Wetherby. None but good strong salmon could, in fact, overcome the difficulties of ascending the river above that place; so that no confusion could possibly arise from a difference of origin.

"Of course I am not so unreasonable as to suppose that my statements on this subject will convince those who have taken up decided opinions to the contrary, but it cannot be difficult to put these statements to a satisfactory test. Let the inmates at the ponds of Stormontfield be carefully examined. No doubt some few will still be left there with the silvery appearance of the smolt. Let one or two of them be examined anatomically to determine their sex. Let the same be done with some of those which now retain—and, if my theory is correct, will be found to retain all the summer—the appearance of parr. Let some portion of these be kept in the ponds until next spring, and it will then be found, if I am not mistaken, that they will assume the silvery appearance, and at the same time the peculiar indigo blue colour of the pectoral fin, which is characteristic of the salmon. A few careful observations directed to test the accuracy of my views on the subject will probably tend to remove an uncertainty which has long and generally prevailed; in which case I shall be extremely glad to have contributed in any degree, however trifling, to the attainment of such a desirable object."—Piscator.

Advantages of the breeding system.

This statement is worthy of consideration. It certainly accords with, if it does not account for, the anomaly already noticed, of the number of mature male parr, and the great rarity of females in the same condition. No doubt Dr Heysham informs us, that he has at different times and seasons examined 395 parr (or samlets, as they are called at Carlisle), and found 199 males, and 196 females. But this may have been when they were intermingled; or he may have counted many females at one time, and many males at another. It does not, however, reconcile the contending theorists. We cannot suppose that certain salmon produce only male ova, and others only female, yet something of this kind must be assumed, to account for Mr Shaw's specimens almost all requiring two years to *smolt*, while Mr Young's never needed more than one. How could the former chance to be almost all males, and the latter almost all females? Another odd circumstance will result from this new view, viz., that no pair of grilse, of different sexes, can ever be of the same age. A brood of young salmon are hatched, say in the spring of 1853. In that of 1854 all the females become smolts, descend to the sea, and return from it as grilse in summer. But their male companions abide for two years in the river, and so have no chance of being grilse till the summer of 1855. On the other hand, the actual male grilse of 1854 must (according to the theory) have been bred in 1852, and so are necessarily a year older than those with which they pair. So also must there be a difference of at least a year in the age of all salmon (as such) of different sexes. A female fish hatched in the spring of 1853 becomes a grilse in the summer of 1854, but all the males of her early acquaintance must wait for their conversion until the summer of 1855, by which time she has herself become a salmon. Her brothers, no doubt, become salmon in 1856, and they are then all in the same state, and also actually of the same age, although the females have the advantage of being in their second year as salmon, while the males (having lost a year in fresh water) are only in their first. Of course there are both male and female smolts descending together to the sea during each and every spring, but according to this new notion the former are two-year-old, and the latter only one. Let this point be henceforward looked to carefully by anglers, and all others who have opportunities of observation. The whole subject of the age of smolts has now become of high importance in an economical point of view, to those who raise the fish in ponds. As a consequence of the annual theory (if founded on fact) being reduced to practice, we shall have it in our power to produce good marketable grilse in fifteen or sixteen months from the hatching of the ova, while, according to the biennial view, that advantage will not be obtained until the lapse of about two years and a quarter. It is like the sudden conversion of "gimmers" into four-year-old mutton, a mutation which the sheep-farmer would fondly see.[1]

Having now endeavoured to explain the prevailing opinions regarding parr and smolts, we shall proceed to consider briefly the third stage of a salmon's life, that which

[1] We are indebted to Mr Robert Buist of Perth for giving us recent information regarding the condition of the parr and smolts of the Stormontfield ponds. It appears that although so obvious a change was observable among the majority by the end of May that they were allowed to take their departure into the river, a great number of a smaller size neither exhibited the same external change nor a like willingness to leave the pond. There they still abide as *parr*, no doubt waiting for the spring of the ensuing year. Some hundred thousand are supposed to have been successfully hatched, and of these Mr Buist calculates that about 130,000 took their departure seawards. Of these about 1300 were marked by cutting off the small dorsal or adipose fin; and several of them have been already captured on their return as *grilse*. The hope is entertained that for every marked grilse that returns, 100 others (also original inmates of the pond) return with it. It may not be easy to ascertain the actual proportion which still remain in the pond. If the original number brought up there amounted to 300,000, then the exodus consisted of not one half. "*One third*," says the Perthshire Courier of 26th July 1855, "of the original stock are still in the pond, and although the sluice has never been closed since it was first opened in May, they manifest no desire whatever to leave it. In point of fact, with perfectly free means of egress, not one of them has left the pond since the general migration ceased at 7th June last. Thus, while one portion of the same hatching are being captured in the river,

Conversion of smolts into grilse.

immediately precedes its adult state—to wit, the condition of grilse. So salubrious is the sea, so enlarging the influence of its wide domain, that no sooner has a smolt of a very few ounces in weight been launched into that vast abyss than it suddenly expands in growth, even as the children of the Anakim. In a couple of months it will then weigh more pounds than it previously did ounces. This great and rapid growth seems to depend entirely upon what the fish obtains in salt water, and the longer it remains there the larger it becomes. The chief run of grilse into the rivers does not take place till summer is well advanced. Very small grilse are sometimes caught in early spring. They cannot then be otherwise than small, because they have chosen to return to the rivers in a few weeks after they had left them as smolts. Larger grilse, but still of small dimensions, are caught in early summer, and they thus increase in size in proportion to the length of their sojourn in the sea. Of course, a smaller grilse may be sometimes caught in August, and a larger one in July, but this quite conforms to the general principle which regulates their growth—the latter having been longest in the sea, as one smolt may migrate early in April, and another not till the beginning of June, some being sooner ready for their journey, because earlier hatched. There is no proof of anything like a lengthened and continuous succession in the migratory movements of smolts. These movements may be in some measure modified by the temperature of the preceding season, and so extend, more or less, over several weeks in spring. Thus, also, the size of grilse and the periods of their appearance vary, but the great mass begin to ascend about the middle of July, by which time they have been nearly three months in the sea. The largest grilse are found in autumn, and the least in spring. We regard this as a sufficient proof that the *smolting* process ceases soon after the commencement of summer. If any parr became smolts in autumn (as some suppose, thereby seeking to account for the continuance of the middle-sized kind in the rivers after spring), and made only a short sojourn in the sea, then we should have small grilse coming up in winter, which is not the case; or if they remained in the sea for a longer time, then we should have large grilse in spring, which is equally well known to be not the fact.[1]

That smolts become by conversion grilse has been satisfactorily demonstrated by Mr Andrew Young. In the spring of 1837 he marked a number of the former, just as they were about to descend towards the sea, by making a perforation in the caudal fin by means of a small pair of nipping irons constructed for the purpose, and in the course of the season he re-captured a considerable number on their return to the rivers, all in the state of grilse, and varying from three to eight pounds, "according to the time which had elapsed since their first departure from the fresh water, or, in other words, the length of their sojourn in the sea." In the spring of 1842 he likewise marked many descending smolts, by clipping off the small ray-less protuberance upon the dorsal line, called the adipose fin. In the course of the ensuing June and July he caught them coming up the river as grilse, bearing his peculiar mark, and agreeing with those of 1837, both in respect to size and the relation which that size bore to the lapse of time.

Note of Smolts marked in the river Shin, and recaptured as grilse on their first ascent from the sea.[2]

Period of marking as smolts.	Period of recapture as grilse.	Weight when recaptured.
1842. April and May.	1842. June 28.	4 lb.
... ...	... July 15.	5 lb.
... ...	... ... 15.	5 lb.
... ...	... ... 25.	7 lb.
... ...	... ... 25.	5 lb.
... ...	... ... 30.	3½ lb.[3]

As the growth of grilse is dependent on the sea, fish in that stage, though necessarily younger, may be of greater dimensions than adult salmon, and for the following reasons:—

beautifully grown grilses of four and twenty inches in length, another portion is still enjoying the shelter of the pond, tiny creatures, none of them more than three or four inches long."

It is impossible at present to say what the effect of superabundant feeding may be in hastening the process of development. If scattering quantities of boiled and grated bullock's liver several times a-day into the ponds, has produced an earlier *smolting*, then the triumph of artificial rearing of salmon stock is all the greater, and the more assiduously should the process be put in practice. We certainly noticed and pointed out to others, during our examination of the ponds, that all those parr which continued to swarm in the small streamlet which flowed from the hatching troughs into the large feeding pond, were much smaller and otherwise less mature than such as swam and fed in the expanded piece of water, in the comparative stillness and extent of which they had no doubt a more ample supply of food, and a greater range of ground, than what were enjoyed by the inmates of the running water. We know from observation that the increased rate of growth in young trout, when their native streamlet has been converted by damming into a large pond, is sudden and extraordinary; and it is possible that the constitutional change which parr undergo in their natural conversion into smolts, may be induced at an earlier period by artificial feeding. Mr Shaw's specimens, so few of which smolted when a year old, were left to their own resources. In the meantime, many considerate people view the combatants in this field as they would the knights of old, who disputed from opposite sides whether the face of the shield was of gold or silver. There are now abundance of undoubted parr still in the pond, though far advanced into their second year, while it seems just as certain that a great multitude took their departure two or three months ago as smolts, and are now returning, there is every reason to believe, as grilse. "So," says Mr Buist, "Young and Shaw will be both right. Young's smolts are off, Shaw's parr remain. What can be the cause?"

The following is a note of the number, weight, and sex of the marked grilse taken in the Tay up to the 4th of August of the same season (1855) as that in which they were marked as smolts. July 7, 3½ lb., a female, taken near the junction of the Earn and Tay. July 20, 5½ lb., likewise a female, taken four miles below Perth. July 24, 5 lb., a male, taken fourteen miles below Perth. July 30, 7½ lb., a male, taken at Perth. August 1, 7½ lb., a male, taken at Perth. August 4, 6 lb., taken near Perth; also one of 7 lb., taken below Elcho Castle, and two others reported, but not transmitted for examination. The sex of these last four was not stated. We may add that our recent observations and reports do not confirm the idea that the female parr become smolts and migrate in one season, and the male parr in another. We now find both sexes among the midsummer parr, the males being sexually developed, the females in that respect immature, that is, with the ovaries but scarcely formed, and only minutely granular in their contents.

[1] Mr Young states that the majority of grilse remain in the sea only for about a couple of months, and he has shown that the longer they remain there the larger they become. He admits that the smallest are caught in spring and early summer, the largest towards the close of the latter, and in autumn. Now if the majority of smolts soon return from the sea, and all that abide in it for a lengthened time become large grilse, what is the result or produce of such smolts, as, according to Mr Young's view, descend to the sea in October? If they return soon they would necessarily be small grilse, if late, large ones; but no small grilse ascend in winter, and no large ones in spring, although that would unavoidably happen, in accordance with his supposition of an autumnal smolting, if that supposition were correct.

[2] See a paper by Mr Young, *On the Growth of Grilse and Salmon*, in the *Transactions of the Royal Society of Edinburgh*, vol. xv.

[3] Our object, in regard to the important points now under discussion, being to ascertain and communicate the truth, we have always great pleasure in receiving information or opinions from people of practical experience. We believe in the rapid transmutation of smolts into grilse as recorded by Mr Young, and confirmed by the corresponding changes undergone by the sea-trout of the Nith (*Salmo trutta*), where their smolts are as rapidly converted into herlings, which are the grilse of that minor species, as shown by Mr Shaw. But we shall here note, as not conforming with those views, the sentiments of Mr Paulin of Berwick, agent for the shipping company there, to whom we are otherwise indebted for some valuable statistical information concerning the salmon fisheries of the Tweed.

"I observe at Perth there is a strong belief that the smolts of this season, which have just lately gone to the sea, will return as grilse

Conversion of grilse into salmon.

One grilse leaves the sea early and ascends into the river, where his growth gains no increase. He descends after spawning, and makes his second return to the river, in early spring, a small but adult salmon. But he may not have been more than six weeks each time, that is, three months altogether in the sea. Another grilse abides continuously in the salt water all summer, and having gone down early (as a smolt) and ascended late, he may weigh 8 or 9 pounds when he goes up the river, being, as a large grilse, heavier than a small salmon. Grilse, then, ascend the rivers, and breed there when their time comes, after the manner of adult salmon. They re-descend to the sea in like manner towards the close of winter, or in early spring, undergoing the same process of deterioration by long residence in the river, and of restoration through marine agency, and on their second return to the fresh waters they are salmon, properly so called.

This conversion of grilse into salmon had been known from an early period of the fish's history. The rate of progress has more recently been shown by Mr Young. He commenced marking grilse as far back as 1837, and has frequently done so since. We shall here record only the result of two successive seasons. In the spring of 1841 he marked a number of spawned grilse of four pounds weight soon after the conclusion of the spawning period, by putting a peculiarly twisted piece of wire through the dorsal fin. They were immediately thrown into the river, and of course disappeared, making their way downwards with other spawned fish towards the sea. In the course of the ensuing summer he recaptured several of them, and found that they had grown in the short period of four or five months into beautiful full-formed salmon, varying from 9 to 14 lb. in weight, the difference depending on the length of their respective sojourn in the sea. In January 1842 he repeated the same process of marking four-pound grilse which had spawned, and were therefore about to seek the sea; but instead of placing the wire in the back fin, he this year fixed it in the upper lobe of the tail. On their return from the sea he caught many of these quondam grilse as before. The following table, which we owe to Mr Young, illustrates the rate of growth.

List of grilse marked after having spawned, and recaptured as salmon, on their second ascent from the sea.

Period of marking.	Period of recapture.	Weight when marked.	Weight when recaptured.
1841. Feb. 18.	1841. June 23.	4 lb.	9 lb.
... 18.	... 23.	4 lb.	11 lb.
... 18.	... 25.	4 lb.	9 lb.
... 18.	... 25.	4 lb.	10 lb.
... 18.	July 27.	4 lb.	13 lb.
... 18.	... 28.	4 lb.	10 lb.
March 4.	July 1.		12 lb.
... 4.	... 1.		14 lb.
... 4.	... 27.		12 lb.
1842. Jan. 29.	1842. July 4.	4 lb.	8 lb.
... 29.	... 14.	4 lb.	9 lb.
... 29.	... 14.	4 lb.	8 lb.
March 8.	... 23.	4 lb.	9 lb.
Jan. 29.	... 29.	4 lb.	11 lb.
March 8.	Aug. 4.	4 lb.	10 lb.
Jan. 29.	... 11.	4 lb.	12 lb.

Size of adult salmon.

We commenced the preliminary portion of our present treatise by an indication of this fine fish in its parental state, and we now complete the somewhat complicated circle by coming round to the point from which we started. There is no proof before us that salmon, after once fairly ascending a river, however early in the season that ascent may be, ever return seawards that same summer. They seem to abide continuously in the rivers till the breeding season commences on the occurrence of cold weather, and do not descend again till they have spawned. The following bears on this important point. Mr Stephen stated, in his evidence before a committee of the House of Commons, that "our cruives on the river Don are so constructed, that salmon of ten pounds weight can at all times go up, but none can descend past the cruives. We fish generally in the pool above the cruives; and if the unspawned salmon returned again down the river, we would undoubtedly catch them there, which is never the case. They are never seen to descend the river except as kelts after having spawned." The after conditions of the adult salmon life being beset by difficulties which no man can number, its ultimate term of existence, and the size to which it might eventually attain, are as unknown quantities, or at least can only be approximately inferred from casual cases. Such individuals as for several seasons succeed in avoiding the deadly and deceptive chambers of the bag and stake nets (*Lasciate ogni speranza, voi, che 'ntrate*), and escape, moreover, the sweeping meshes of the boatmen, the wily prison of the darksome cruives, the angler's gaudy lure, and the poacher's relentless leister, will no doubt continue to increase from year to year. But such are now the multiplicity and perfection of our various fisheries, and so great the facilities for preserving and transmitting this princely and highly-prized species from even our far northern rivers, to the luxurious cities of more southern districts, that it may be greatly doubted whether any British salmon ever attains to a good old age, or dies a natural death. We therefore possess but few data from which to judge of either their natural term of life, or their final dimensions. They are still occasionally, though rarely, killed of the weight of forty, or even fifty pounds. But these are giants of their race. We know, however, that a few years ago, in the then comparatively slightly-fished rivers of Norway, salmon of those sizes were by no means uncommon; and it is authentically recorded that even in this country, and in our own days, a female fish came into the possession of Mr Groves of Bond Street, which weighed 83 lb. Pennant had previously recorded one of 74. We shall here note one or two cases of the ascertained increase of size in adult salmon. In the year 1841 Mr Young marked some spawned salmon by means of copper wire. One of them which had been marked on the 4th of March, when it weighed 12 lb., was recaptured on its return from the sea, on the 16th of July, weighing 18 lb. He found that the majority of his marked fish did not continue absent more than two months, and his experiments not only demonstrated this fact, but another of great consequence to the breeder of salmon—

in July and August next. From my own experience I think this will be found not to be the case, although among the fishermen it was the universal belief only a few years ago. In *May* 1851 there were a great many smolts in the Tweed marked by a silver wire being put in their tails. At this time they could not be above two or three ounces in weight, and the first of them that was caught was in *August* 1852, when it weighed four pounds four ounces. There were several others taken during the same season, some with the wire in the tail, and others with the mark of the wire worn out, so that the experiment was very satisfactorily proved, and one of the specimens is preserved in spirits in the Tweed Commissioners' office until this day. It would appear, therefore, that grilse are the smolts of the *second year*, but to what part of the sea they retire during the intermediate time is yet a mystery.

The rapid growth of the grilse has been argued as a reason for the belief that they are smolts of the *first* year. When they first make their appearance in April or May, they are certainly found to be less than two pounds in weight, and before the end of the season (15th October) many of them weigh perhaps as much as seven or eight pounds; but taking the average of seven years (1845–1851) I found the growth to be as follows:—

Average Weight of Tweed Grilse—June, 3 lb. 3 oz.; July, 4 lb. 7¾ oz.; August, 5 lb. 2½ oz.; September, 5 lb. 10½ oz.; October, 6 lb. 11 oz.

Now it is almost impossible to believe that a fish weighing only two or three ounces in April or May should increase in its growth with such rapidity as to weigh fifty-five ounces in June (which would be twenty times its weight in six or eight weeks), while the same fish, weighing 3½ pounds in June, does not double its weight in the next four months ensuing."—MS., 29th June 1855.

Varieties of salmon.

that these fish invariably (if permitted so to do) return to the rivers in which they have been bred. Mr Young's position was peculiar in the opportunities which it afforded for the ascertainment of this feature in their history. Although five good rivers fall into the estuary, or central course of the Oikel, the marked fish were always found again, each in the particular river in which its badge had been imposed; and although all these rivers fall into the same estuary at different places, and the fish must come up promiscuously together through the briny waters of the lower portion for twenty miles, each river has its own peculiar race, and each race always finds out and enters its own river.

"The first of these rivers," says Mr Young, referring to the upper portions of the so-called Dornoch Frith, "that falls into the estuary, has a run of well-shaped salmon, whose average weight is about 10 lb. The second has strong, coarse-scaled, rather long to be well shaped, but very hardy salmon, whose average weight is about 17 lb. The third has a middling-shaped fish, whose average is about 9 lb. The fourth river has long ill-shaped salmon, averaging about 8 lb. And the fifth river, though the smallest of the five, has fine-shaped fish, averaging fully 14 lb.; and although the fish of all these rivers mix together, and all travel together on the common road to the sea, feed there promiscuously on the common feeding ground, and then return by the same common path, each party finds out its own home with the greatest precision, for scarcely ever is one of them seen in its neighbour's possessions. This precision is yet a mystery, among many others; for although we see rivers of different temperature arising from the size or situation of lakes from which they are fed, we find others of the same situation and temperature, and yet the fish must know a distinctive quality that leads them to their own native streams. It is true that salmon have their summer and winter courses for travelling in the same river, and that is also kept with the most exact precision; for in winter, and up to the first of May, salmon invariably run up the north side of rivers, whereas from 1st May to November they run on the south side."[1]

The most remarkable instance of rapid return, with extraordinary increase of growth, of any salmon we have ever heard of, is that recorded by the Duke of Atholl. A fine fresh-run fish, much exceeding the ordinary size, was transmitted to his Grace from the lower portion of the river Tay. It bore the badge of "No. 129." "On referring to my journal," observes the Duke, "I find that I caught this fish as a kelt this year on the 31st of March with the rod, about two miles above Dunkeld Bridge, at which time it weighed exactly 10 lb.; so that in the short period of *five weeks and two days* it had gained the incredible increase of 11 *lb. and a quarter*, for when weighed here on its arrival, it was 21 lb. and a quarter."[2]

That all the individuals of the fish commonly called the salmon (*Salmo salar*) belong to one and the same species, we entertain no doubt, although the *variations* of that species are considerable. Whether these are original conformations, or the result of local influences, it would be hard to say. That the fish of each river naturally desire to return to that river is also an ascertained fact; and it is by taking advantage of the facilities afforded by that strong and steady instinct that the age and growth, within a certain period, of individual salmon (and so approximately of the whole) have been ascertained. In one river a large breed of salmon is found—so large as to average nearly eighteen pounds in weight—while in another almost adjoining, that is, in the same district, the breed is so small as not to exceed an average of seven pounds. In some rivers the salmon, even in their best condition, are long and lank; in others broad and short, so much so, that when cut up their transverse section is almost circular. In one river we may find all the salmon nearly straight along the dorsal line, while in others they are rounded or hog-backed. In some places all these fish have large and clumsy heads; in others that part is small and neat. Even in the very variable character of spots and scales, there is often an obvious, that is, a permanent or abiding difference. Mr Fraser has stated that in the Ness and its branches there are three sorts or varieties of salmon—one with three rows of spots, one with four, and one with five, exclusive of the difference in shape and size. But it is the difference in the river that generally manifests the difference in external aspect, and this, when dimensions are concerned, is still a mystery. All salmon gain their growth in the sea, and the same marine food (whatever it consists of) is open alike to the natives of all rivers. The waters which flow through the Kyle of Sutherland, and, becoming confluent with the Carron, discharge themselves into the head waters of the estuary of Dornoch, near Bonar Bridge, have each, as we have said, a distinguishable kind of salmon; and those which eventually enter the Shin are twice the size of most of the others. Yet they must seek the same parts of the sea by the same channel, and while *parr*, or during their early period of fresh-water growth, seem as well fed in one river as in another. As the increase of growth undoubtedly depends on sea-feeding, it is less easy to understand the cause of difference when the feeding is the same. Why has a Shin parr the power of becoming a much larger salmon than one from the Oikel? Or how have the Shin salmon sprung up into a large race under apparently the same physical conditions as those with which, in the sea and estuary, they are intermingled? If the growth was in the river, then we could comprehend how great differences in size might result from existing differences in the breadth and depth, as feeding grounds, of our multitudinous and very varied streams. But as it is known that fresh waters have nothing to do with the growth of salmon after they have ceased to be either parr or smolts, and the fish of one river cannot appropriate to themselves any marine food distinct or different from that which is also at the option of all the others, we find it more difficult to understand how a large average size of fish should result from one river, and a small average size from another near it. But so it is.

Before proceeding to take a view of the commercial bearings of the subject, and the modes by which these fish are captured, we shall inquire briefly into the laws which regulate that capture, and constitute the legal rights of the captors.

[1] *The Natural History and Habits of the Salmon*, London, 1854.

[2] In regard to this marking of grilse and salmon, the following apprehension has sometimes come into our mind. It is easy to suppose an individual of high rank, great wealth, and large public spirit, taking pains to mark certain fish, and record their re-capture after a certain time. To secure or induce their restoration when caught by others in some far-distant portion of the river, a reward is probably promised (besides the market value) to whoever takes and delivers up the marked fish on its re-ascent from the sea. If the identical fish is re-produced, and the times and weights compared, of course the rate of growth is correctly ascertained, and may be relied on as a fact. But it is also quite as easy to suppose an individual of low rank, no wealth, and as little public spirit, catching, by leister or otherwise, a 10-lb. marked kelt on its way downwards. He removes the mark (kippers the kelt), and in due time attaches it to a fresh-run fish of 17 lb. 8 oz., which he carries as quickly as he can to some palatial residence where rich men congregate. The fact is easily ascertained that the latter fish now weighs 7½ lb. more than did the former when laid in the balance; but is it equally an ascertained fact that the original kelt has really gained that increase in a given time? These observations do not apply to such practical experiments as Mr Young's, conducted from first to last by the same individual, seeing with his own eyes, offering no reward to any one, and having the great advantage of the entire control of a short though productive river. Mr Young can keep the Shin, as it were, under lock and key.

Regulating laws of salmon-fisheries.

By the law of Scotland salmon-fisheries are regarded as *inter regalia*, and the result of this is that they are not carried by a general grant of the lands and their appurtenants in any grant holding of the crown (which is the way in which all land rights are held in Scotland ultimately), but must be the subject of special grant, either express or implied. The subject of the former is, where a charter is given by the crown expressly *cum piscationibus salmonum*. An implied grant is where the words used may be simply *cum piscationibus*, without any addition of *salmonum*, or where the grant is of a barony. In the former of these two later cases, if the salmon-fishing has been possessed by what is accepted as a legal mode of possession—not simply fishing with the rod, which is not so regarded, but by some greater, we shall not say nobler, exercise of the right of fishing;—if the salmon-fishing has been so possessed under a grant *cum piscationibus* simply, the salmon-fishing will be carried. With respect to the grant of a barony, it is doubtful whether a mere grant with possession gives prescriptive right. Lord Rutherfurd has stated his opinion that the grant of a barony, followed by possession of salmon-fishing, exercised by some higher species of possession than that of the rod, would carry the grant of salmon-fishing also. Scotch salmon-fishings do not require any parliamentary ratification, and the grants are equally good at whatever period they have been made. There is no reason why the crown should not now make a grant of salmon-fishing which shall be quite effectual to the grantee, provided, of course, it does not interfere with any previous grant already made by the crown, whether that previous grant is expressed or implied, and if in the latter case it has been made effectual by prescriptive possession. To establish a right in Scotland the period of prescription is forty years; but the possession for that time, to establish the prescriptive right, must proceed upon what is termed a sufficient title. It is a sufficient title, in the case of salmon-fishing, if there has been continuous and uninterrupted possession for forty years following the grant simply *cum piscationibus*, or the grant of a barony. Salmon-fisheries, in Scotland, belong to the crown by beneficial title, and not merely in trust for the public, after the manner of highways. Thus all grants of salmon-fishings hitherto made by the crown have been for a consideration, although, through favour to the subject, the payment may be made illusory, as a penny yearly, or the blast of a horn. This right of salmon-fishing has been very extensively granted by the crown along the shores of navigable rivers and on the sea-coasts, and may be quite distinct from the possession of the land upon the banks or shore. Thus the grant of a salmon-fishing may not be the grant of the shore on either side of the river—the party may not be the grantee of the shores of the estuary, or the coast of the sea. These regal rights were not constituted by any acts of the Scotch parliament, but are part of the immemorial law of Scotland.

There are three natural positions in regard to which salmon-fishings may be the subject of royal grant in Scotland. First, they may be simply upon the sea-shore, and in the sea, and at such a distance from the mouth of a river that they cannot be considered as part and parcel of any other fishing, either of river or estuary. These being less special than the others, and impinging upon the open or public sea, have been less jealously regarded, and there is no doubt that many shore proprietors, with no deputed right from the crown, exercise that right erroneously, though to their own advantage. Secondly, these salmon-fishings (in this case often of great value) may be in what are called estuaries, a somewhat ambiguous term, differently construed at different times and places, but the fisheries of which the ancient Scotch acts of parliament define as being "in fresche watteris, quhar the see fillis and ebbis," and "upon sand and schauldes far within the water." The third position in which salmon-fishings may be carried on is in pure rivers, where the water is always fresh, and always descending.

As there is a prohibition by statute of all fixed machinery for the fishing of salmon in the "rivers" and "waters" of Scotland, where the sea ebbs and flows, disputes have not seldom arisen (from the difficulty of applying the principle to special localities) between the seaward proprietors who desire to extend the region of stake-nets riverwards, and the upper proprietors who equally desire to drive them downwards. It has been held, according to Mr Bell—1st, that the prohibition extends to all rivers and estuaries to the fullest extent to which the sea ebbs and flows, and down to the *fauces terræ* at the mouth of the firth, and the sands dry at low water, as well as in the channel; 2d, that it does not comprehend the proper shores of the sea; 3d, that stake-nets are prohibited in the land-locked estuary of a river, being the intermediate space between what is strictly the river and strictly the sea, but where the river and fresh water still exists with predominating influence; and that they cannot lawfully be placed either in the channel of such river or estuary, or on sands which are left dry by the ebbing of the sea; and, 4th, there is an exception in the statute of 1563 (prohibiting machinery where the sea ebbs and flows), "that it shall not be extended to the cruives and zairs being upon the water of Solway," which is the subject of particular regulation, being a border fishery.

The protection and encouragement of the breed of salmon in the rivers of Scotland appear to have engaged the attention of the legislature from a very ancient period, and numerous enactments have been passed from time to time. Some of these related exclusively to the *regulation* of the cruives or other engines in which the fish were caught, without reference to the localities in which they might be placed; and it seems not improbable that originally this matter of regulation was the thing chiefly in view. But in progress of time, when the importance of the fisheries began to be felt and acknowledged as a great branch of international wealth and source of subsistence, other laws were enacted, not merely to regulate the cruives and zairs, but also to prohibit them absolutely in certain situations where their existence was ascertained to be adverse to the important object of maintaining the breed of fish. With this purpose in view, a numerous series of enactments was passed from the reign of James I. down to the union of the two kingdoms; and in one respect those enactments proceed invariably on the same principle. While they permit cruives and other kinds of fixed machinery in the *fresh* waters of rivers to which the tide does not extend (subject to certain regulations and conditions), they absolutely prohibit all such machinery below that point, or within the influence of the tide. They prohibit it "in fresche watteris, quhar the see fillis and ebbis,"—"in watteris that fillis and ebbis,"—"in rivers that has course to the sea," and "within the fludemark of the sea,"—"in waters quhair the sea fillis and ebbis,"—"within salt watteris, quhar the sea ebbis and flowis,"—"within salt waters that ebbis and flowis,"—"upon sands and schauldes far within the water," and in general "upon the water sandis."

An estuary is admitted to be different from a river, and the difference is constituted by a certain intermingling of marine features. The ascertainment of the upper portion of an estuary, where it is gradually lost in the river, is, we presume, a point not mooted in any stake-net question, which rather seeks to determine the lower limit of the estuary, where the remnants of its fresh-water characters fade away, and its marine ones increase, to the eventual entire exclusion of the others. It is clear that where a river discharges itself upon an open coast at once into the sea, its independent character is almost instantaneously destroyed, without the intervention of any estuary or other debateable region. The ocean waters are so boundless and redundant,

Debateable waters.

those of the river so narrow and restricted, that no effect is produced upon the former by the latter. This is the case with one of our noblest streams at Tweedmouth, where we have river and sea, yet no estuary. But where the river, as in the instances of Tay and Oikel, has to work its way through "sands and schauldes," and along the centre of what, in comparison with the open coast, may be called an inland valley, the basin of an extensive watershed on either side, and which receives at its head a confluence of rivers flowing from remote and ramified upland districts, the position of affairs, as between salt and fresh water, becomes entirely changed. There we have a small, confined, and shallow sea, crossing, it may be, an obstructing bar or other sand-bank, its force during flow being exhausted by having to expand over wastes of mud and shoals of gravel; its saltness decreased, and ere long destroyed, by the influence of the multitudinous streams and rivers which rush ceaselessly by night and day into its bed (to say nothing of an extensive though unobservable drainage from the land); and the sea itself, such as it is, allowed to advance so far inland merely by the flatness of the upper portion of the landward basin.

The term estuary, though not seldom very vaguely applied, is always intended to signify such waters as lie between the undoubted fresh-water river and the firth or sea. An arm of the sea (such as Loch Fine, Loch Sunart, and others, on our western shores) is a lengthened body of marine water entering inland, and varying in height with the state of the tide as relates to ebb and flow, but never withdrawing itself from its retentive basin, the productions of which are essentially marine. The purest of all sea water is of course that found at a great distance from land, where neither animal nor vegetable productions are at all abundant, and where even birds and fishes, each and all of whom are "winged messengers" in their way, are much less numerous than nearer shore. The closer, within certain limits, we approach the coasts, the more abundant are marine productions. But as we ascend firths, and enter the mingled waters of estuaries and the fresh ones of rivers, these gradually diminish, and eventually disappear.

It has been argued that the ascertainment by philosophical investigation of some single great physical fact, such as the precise point inland at which the tide is always either ebbing or flowing, would and ought to determine the disputed question, as to where the sea ends and the estuary commences. This, of course, would be where the fresh water of the river meets the salt water of the sea at lowest ebb; a theoretical test not likely to have been much in the minds of Scotch barons in the days of Robert the Bruce, and which, if applied in our own days, would destroy at least the majority of the net-and-coble salmon-fishings throughout the country. Mr James Jardine, our eminent civil engineer, was the first to point out and ascertain this test for determining where a river ends and a firth begins, having been employed in that investigation in 1810, in the great Tay case, the Duke of Atholl *v.* the Honourable William Maule. Mr Jardine gave in a report, in which he professed his object to be, to inquire into such circumstances in regard to the localities of the Tay, "as might seem of importance in determining the common boundary of the firth and river;" and among the various points which he states as ascertained are the following:—First, that of the common section of the mean surface of the sea and river, which he determined to be at a place called Friarton; secondly, the line in the firth above which the sea-ware ceases to grow; and, thirdly, the point of the lowest ebb in the channel of the river. That part of the report which relates to the last-mentioned point, is entitled "Of the highest point at which the sea is always either ebbing or flowing," and under this head we have as follows:—"From a series of observations on more than fifteen tides, it was found that the highest point at which the medium tide was always either ebbing or flowing, was immediately above the confluence of the Earn and Tay. This determination, however, must be considered as less accurate than could be wished, on account of the advanced season of the year in which the observations were made." The report then concludes with a general summary. "Having thus examined in detail the several circumstances proposed, I am led, in estimating their comparative importance for determining the common boundary of the river and firth of Tay, to lay the greatest stress on the three last, particularly on that which determines the highest point at which the tide is continually ebbing and flowing. This boundary cannot, I think, be placed higher than Friarton, where the common section of the mean surfaces of the sea and river has been shown to take place; nor can it be lower than the line which stretches across the firth from Errol-Dyke to the stone above Bambreich Castle, where the sea-ware ceases to grow. It appears to me, therefore, that the confluence of the Earn and Tay is the proper place of the boundary in question, since it is nearly the mean between the limits above mentioned; is the commencement of the character of a river, as indicated by the appearance of gravel; and, lastly, is the highest point or place where the medium tide is continually ebbing or flowing." To this Professor Playfair added a brief opinion, in which he states, that "the highest point in the river where the tide is continually either ebbing or flowing, furnishes, in my opinion, the best criterion for ascertaining where the firth ends and the river begins; it is a rule applicable in all cases, and much more definite than what could be deduced from the mean level of the sea, the saltness of the water, or the growth of sea-weed,—all of which, however, Mr Jardine has determined in the present case with all the accuracy of which their nature would admit. This criterion, therefore, which I believe to be new, is valuable, not only as applicable to the present and all similar questions, but as establishing an important fact in the natural history of rivers."

We believe that no single character or criterion can be adopted in the solution of this question as it bears upon salmon-fishing. That referred to, however interesting as a question in hydrology, or the geography of physics, is certainly not the test of the statutes, and their construction in accordance with it would, in most cases, exclude the greater portion of the space which falls within their meaning and consequent protection. The adoption of what is called the *medium level* of the sea would of course be still worse. That level, for example, cuts the *surface* of the river Tay at *Friarton*, and the *bottom* at the Townford, and so would carry the fixed engines above the best regions of the net-and-coble. The same point, in relation to the estuary of the Oikel, would carry the sea several miles above Bonar-Bridge, where the water is fresh even at high tide, and where at ebb the river descends with all the rapidity, and a thousand times the strength, of a mountain torrent. We believe that each estuary must be tried upon its own merits, so greatly do those inland reaches differ in their natural character and conditions. The sea is a great intruder, and is sure to find its own level in spite of all opposing obstacles. If, in pursuit of such level, it flows over vast hollow basins, and into lengthened ravines of great depth, scooped out into the very bosom of the loftiest hills, as is the case in all our western lochs (Sunart, Nevish, Hourn, Alsh, Torridon, Broom, Laxford, &c.), it necessarily abides there continuously and for ever, in the ratio of the excess of depth over the difference between high and low water; so that if the actual depth of these great sea-lakes is one, two, or three hundred feet, a difference of 12 or 16 feet (consequent on the rise and fall of tide) makes really no alteration upon them whatever. They are essentially the same at low-water as at high, and are arms or branches of the sea, not estuaries. Though goodly streams may pour into them abundance of

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sweet water, the general watershed above and around them is quite insufficient to deprive them of their strictly briny attributes, and their steep cavernous shores are haunted habitually by lobsters and other truly marine creatures, and visited periodically by millions of herrings, which, as in the branching lochs of Shieldag and Torridon, or the still deeper indentations of lochs Dhu and Cul, between Assynt and Edderachillis, swim up in glittering hordes to the very bases of the inmost hills. It is this character of depth, and consequently of *abiding quantity*, which in truth distinguishes the western sea-lochs from the so-called firths upon the eastern side of Scotland.

It is equally clear that fresh water, being specifically lighter than salt, can never so plunge beneath a depth of sea as to make and keep an *alveus fluminis*, or maintain any permanent or influential character of its own, after meeting a great mass of *abiding* sea-water. It reaches at once its final bourne—has no struggles to endure with sands and shaulds, but sinks into immediate insignificance among the great sea-waters. The consequence is, you may have herrings, haddocks, codling, skate, mackerel, and many other fishes, up to the very inmost parts of these saline branches, where also lobsters and other crustacea, with oysters, and more of the testaceous class, rejoice respectively in holes or flatter scalps, over which fresh water cannot flow.

But if the sea far below its line of lowest ebb is extremely shallow and of small extent, if it be so broken up by "sands and shauldes far within the water," and encompassed by a broad continuous stretch of gravel and slimy or alluvial sand, on either side, so as to present at low water an appearance along shore as if there "was no more sea;" these are characters different from those just alluded to, and which form most important elements in estimating the true attributes of a particular locality, of which the essential features result from differences in depth and quantity. Most of the exposed space may (and indeed must) be below the medium level of the ocean, but this is not the question, which, in truth, does not concern levels. That question we conceive mainly to be, the proportional power and influence of the salt water over the fresh, or *vice versa*, because by that power, one way or other, are marine or fresh water productions respectively encouraged or destroyed. Now, it seems clear, that if the sea in its usual state at low water, is merely commingled with and partly overcome by the *linum fluminis* which pervades its centre, and constitutes its main channel; and even after the completion of its upward flow, has still spread its shallow waters only over the bare and broad expansions, before mentioned, upon either side; if the actual quantity of fresh water poured in above and around remains the same, the *proportional* quantity of that water must depend upon the mass of sea with which it is required to mingle; or, in other words, the solution of the question, "Sea or estuary?" must depend almost entirely upon the depth of the trough into which the river falls.

The machinery permitted in pure rivers or streams of unmixed fresh water, in which the sea does not ebb or flow, is regulated on the principle, that there shall be a sufficient passage left for the descent of the young fry, and, to a certain extent, for the ascent of the full-grown fish. The hecks, or open frame-work of all cruives, must be pulled up every Saturday evening during the fishing season at 6 o'clock, and the space remain open till the same hour on Monday morning.

A general belief prevailing that bag-net fishing for salmon was practised along our shores by parties not legally entitled to exercise that privilege, the advisers of the crown have recently interfered by bringing an action against a Kincardineshire proprietor for fishing along shore *ex adverso* of his own lands. These were the lands and barony of Portlethen, belonging to Mr Ernest Gammell, and possessed by him under a charter from the crown, in which they are described as "All and whole, &c., with the seaport, haven, and harbour of Portlethen, and whole tolls, duties, customs, and anchorages pertaining and belonging thereto, with the white fishings in the sea adjacent to the said lands, and whole privileges and pertinents thereof, all lying within the parish of Banchory and sheriffdom of Kincardine, now erected into a free barony, called the barony of Portlethen," &c. The property is situate to the southward of Aberdeen, and is bordered by the open sea. The action was brought at the instance of the Lord Advocate, on behalf of the commissioners of the woods and forests, against the proprietor and the lessees of his salmon fishery, and on the expressed ground that all salmon fishings around the coasts of Scotland, and in the navigable estuaries, bays, and rivers thereof, so far as the same have not been granted to any subject by charter or otherwise, belong to the sovereign *jure coronæ*, and form part of the hereditary revenues of the crown in Scotland; and that as the charters of the defendant and his predecessors contain no such grant of salmon fishings, he has no right, &c., and never attempted to exercise that right till within the last few years. The prosecutors for the crown had offered to grant a lease of these salmon fishings at a moderate rent, which the defender had declined. The defences were as follows:—1. Mr Gammell being proprietor of lands erected into a barony, the right of salmon-fishing in the adjoining water is attached thereto. 2. The right of salmon-fishing in the sea does not belong to the crown as part of its hereditary revenue. 3. The right of fishing within the British seas is a privilege belonging to, and may be exercised by, all British subjects, and cannot be constrained, or defeated, or interfered with by the crown. 4. According to constitutional law, the right to public fishings vested in the crown is a right of protection for the benefit of the subject, but is not a right of property. 5. The right of salmon fishings in the sea is not *inter regalia*, and therefore the crown has no right to grant it, or any other right which will apply to the fishes of the sea, or interfere with the rights and privileges of the public. 6. The defenders being entitled to take fishes in the sea, and the crown having no right to interfere with the exercise of their constitutional privileges, they are at liberty, and have the legal power of using and erecting such apparatus as they may consider best suited for the purpose of taking and catching fish in the sea.[1]

The question was argued before the court, as regarding a right at common law (the alleged right by charter, which is the first defence, being waived for the time), and the defences were repelled by a majority of the judges, that is, a verdict was given for the crown, by sustaining the first conclusion of the summons—that the salmon-fishings around the sea-coast of Scotland belong exclusively to the sovereign, and form part of the hereditary revenues of the crown in Scotland, so far as not expressly granted to any vassal.[2]

In England, as we understand, the general law is, that

[1] It appears to us that the above defences, all except the first, proceed upon an assumed *public* right, irrespective of the private possession of the adjoining land, and so would throw the right open to all British subjects. We are therefore anxious to know what Mr Gammell would do if half a dozen traders from Aberdeen, and a like number from Stonehaven (the place in question lies exactly half way between the two), were to take a fancy for Portlethen salmon, and erect a few bag-nets on each side of the same. Would the proprietor, acting upon his own principles of law, insist that they should not be "constrained, or defeated, or interfered with?"

[2] It is understood that some of the judges were dissentient from the actual interlocutor, and the Lord Justice-Clerk Hope, especially, expressed his opposing view, strongly and at considerable length. His lordship was of opinion that the line of argument pursued confounded two distinct things, the *jus regale*, and the hereditary revenues of the crown; and he knew of no authority to consider the former as of the same legal character, or as forming part of the latter. The right to make grants of salmon fisheries in rivers is not equivalent

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no right of fishing can be acquired by an individual upon the sea-coast, or in a navigable river, unless by prescription as ancient as the reign of Henry II., or by act of parliament vesting such right in that individual. So jealously have the rights of the public been protected in England, that there is said to be no instance since the passing of the Great Charter of a grant of free fishery being made by the crown, submitted to by the public, and allowed in a court of justice. No such grants as those so frequent in Ireland have been made in England since the days of John, and there is no English authority for saying that they could be made.

Lord Mansfield states the rule of law to be uniform. In English rivers not navigable, the proprietors of the land have the right of fishing on their respective sites, and it generally extends *ad filum medium aquæ;* but in navigable rivers the proprietors on each side have it not, the fishing is common, it is *prima facie* in the king, and is public. All the authorities concur in declaring that the right of fishing in the sea and public navigable rivers belongs not exclusively to the king, but is common to every one of his subjects. So clear is this, that a plea of prescription of common right of fishing in the sea, as appurtenant to certain lands, has been held to be as idle and absurd as a claim of travelling on the king's highway, or breathing the common air, as appurtenances to a certain estate. Sir Matthew Hale thus expounds the great charter:—Before the statute of Magna Charta, chap. 10, it was frequent for the king to put as well fresh as salt rivers *in defenso* for his recreation, that is, to bar fishing or fowling in a river till the king had taken his pleasure and advantage of the writ *defensione ripariæ,* which anciently was directed to the sheriff to prohibit riviation in every river in his bailiwick." "Riviation," adds Blackstone, "I suppose is a word which implies fishing rights. I never saw it elsewhere." The great charter having been extorted from King John, to prevent a recurrence of illegal encroachments, the construction put upon it in the courts of justice has been, that it is only declaratory of the common law. All the old enactments regarding England are alleged to have been made applicable also to Ireland by the 10th Henry VII. cap. 22. This last is usually called Poyning's act.[1]

Sir Mathew Hale states, that public rivers for the common passage of vessels, whether large or small, are "highways by water," and as much under the control of the king as "the common high-ways on the land;" "and as the high-ways by land are called *altæ viæ regiæ,* so these public rivers for passage are called *fluvii regales* and *haut streams le roi,* not in reference to the propriety [property] of the river, but to the public use; all things of public safety and convenience being in a special manner under the king's care, supervision, and protection; and therefore the report of Sir John Davis, of the piscary of the Banne, mistakes the reason of those books that call these *streams le roi,* as if they were called so in respect of propriety, for they were called so because they are of public use, and under the special care and protection of the king, whether the soil be his or not." Schults says, "A high-way is called in the old books *le haut chemin le roi;* yet it was ad-

to the proposition that all the salmon in the rivers of Scotland, if not granted out, form part of the hereditary revenues of the crown. The right is derived from this, that a salmon-fishery being a *jus regale,* that is, one of the higher rights of property, supposed by fiction to be peculiar to the monarch personally for his own sport or pleasure, and so reserved from ordinary grants, must be given specially with a view to its being devolved upon a subject. But assuredly no one has ever said that the salmon of all the rivers in Scotland formed part of the hereditary revenues, that is, of the proper patrimony of the crown, for if so, then no grant whatever would be competent, being struck at as an alienation contrary to the statutes. His lordship apprehended that there was no authority whatever for holding salmon-fishings to be any part of the hereditary revenues of the crown, or for regarding a *jus regale* as a portion of those revenues. After a careful review of the authorities regarding *jura regalia,* he had satisfied himself that none of them includes, or was intended to include, salmon-fishings in the sea proper, and that all the writers are treating of those mouths of rivers so often called sea or salt water, in reference to the flow of the tide, and it may be in one or two cases land-locked bays, which seem to be within the proper line of the land coast, and included as it were within that line. The argument founded on the fact that grants had actually been made by the crown of salmon-fishings which were said to be in the sea, was, in his lordship's opinion, inconclusive in point of principle, and weak even as a matter of practice, most of these grants being really in firths, estuaries, or the mouths of rivers, or at a turn where the coast begins to trend off, and where it is difficult to say where the proper sands of the tidal river cease. This he believes to be the explanation of the expression used,—of fishings as well in salt as in fresh water, *in aquis dulcibus quam salsis.* That some grants have been made of salmon-fishings in the sea proper is undoubted; but this may be accounted for by the manner in which grants were formerly obtained from the Scotch exchequer, of subjects which ought not to have been so granted, and to which the crown had advanced no claim, a practice stopped by Baron Hume. "It by no means follows that the rights of salmon-fishings enjoyed by the proprietors who have obtained such grants are therefore not maintainable as valid rights of fishing; although I do not think that the right depends on the grant, I think a station on the shore, or in the sea for stake-nets, bag-nets, or other such machinery, is quite capable of appropriation by the proprietor of the lands *ex adverso,* as a fair adjunct to his property, and a natural use for him to make of the coast, so far as he does not interfere with the right of navigation." "I have no doubt that proprietors, without any such grants, will be able successfully to defend this appropriation of the sea-shore or stations in the sea, as a fair adjunct of their right of property. The plea of the crown would equally prevent the proprietor fishing by net and coble—and the summons distinctly goes that length—and catching salmon by long nets swept out by a boat, and then drawn into the shore; a use of the sea-coast which, I am of opinion, the proprietors may make for salmon as well as for white fish, and the denial of which seems to me to be totally repugnant to all notions of constitutional or feudal law which I have ever heard. I may further add, that I am satisfied that the legislation as to stake-nets and fixed engines was limited in the Scotch statutes to estuaries, where the sea ebbs and flows, and was not extended to the sea, because the legislature only intended to regulate fishings which were the proper subjects of exclusive grants, and did not intend to apply such regulations to the general right common to all, to fish salmon as well as other fish in the sea." "I see that a distinction is attempted to be taken between fishings *in alto mare* as something different from the fishings along the sea-coast. That distinction seems to me wholly to fail, and in the authorities "in alto mare" is used as contradistinguished from the sea in estuaries, but directly as applicable to the sea along the open coast of the island."—*Cases decided in the Court of Session,* &c.—(Messrs Tennent, Fraser, and Murray's *Reports*)—vol. xiii., p. 866.

It will thus be seen that some "glorious uncertainty," so far as great difference of opinion is concerned, still pervades this important question. Meanwhile the ruling judgment maintains the general doctrine of the law of Scotland to be that salmon-fishing is a beneficial interest, and remains with the crown, unless it has been conveyed away. That doctrine is not made to depend upon special situation; but upon the object and nature of the operation. It is true that the localities most generally resorted to were rivers, estuaries, or other inlets, because those situations afforded the greatest facilities for catching this particular fish, which is remarkable for its instinctive desire to leave the open sea and ascend the restricted waters. Our earlier salmon-fishers feared the "injurious sea," because the howling winds and rolling waves were too much for their comparatively feeble gear. "But if in process of time," says the judgment just referred to, "it was discovered that even upon the open coast the possession of the shore might be turned to account for the same purpose, it would be difficult to see in principle why the accommodation afforded by the possession of the coast for the purpose of salmon-fishing should be held to have been carried by the crown charter (meaning a charter without a special grant, *cum piscationibus salmonum*) any more than if the lands had lain along a river or estuary," p. 862. It was well observed by Lord Medwyn that the recent statute, 7th and 8th Vict., cap. 95, which declares that a penalty may be inflicted on any person who shall fish for salmon in the sea within one mile of low-water mark, without permission of the proprietor of the salmon-fishery, necessarily recognises the royal right as one pertaining also to a *sea-fishing.*

[1] A compendious statement of the Fishery Laws, as concerns England and Ireland, will be found in the *Dublin Review* for Nov. 1841.

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judged by the whole court, that all profit arising therefrom, and trees growing thereon, belonged to the lord of the place; and again, that every one has an interest in the king's high-way." Hale compares the king's "right of propriety or ownership" in the sea and its branches to that of the lord of a waste or common, and says, that although he "is owner of this great waste, and, as a consequent of his property, hath a primary right of fishing in the sea, and the creeks and arms thereof, yet the common people of England have regularly a right of fishing in the sea, or creeks or arms thereof, as a public common of piscary, and may not, without injury to their right, be restrained of it unless in such places, creeks, or navigable rivers, where either the king or some particular subject hath gained a propriety exclusive of that common liberty." And the latest writer on the subject says, "All the writers on the common law of England agree that the supreme dominion or jurisdiction of his British seas belongs to the sovereign as the head and representative of his people, and that the free and universal right of fishing and navigation in such seas, ports, and arms of the sea and navigable rivers exercisable under his jurisdiction belongs to the subjects in general. The right of fishing in these seas never was vested in the crown exclusively, and of course is not to be considered as a legal franchise. As a public right belonging to the people, it *prima facie* vests in the crown; but such legal investment does not diminish the right of the subject, and is merely reposed in the crown for the sake of regulation and government." [1]

We shall now endeavour to illustrate the past and present condition of the salmon-fisheries of Scotland, by exhibiting the returns of the river Tay, the greatest and probably the most productive we possess. We shall confine ourselves, in the first place, to the two principal fishings of the upper portion of the estuary.

Table showing the Produce of Lord Gray's and Sir Thomas Moncrieffe's Fishings for five periods of ten years each.

Before the erection of Stake Nets.					During the existence of Stake Nets.					After the removal of Stake Nets.				
Ten Years.	Kinfauns.		Moncrieffe.		Ten Years.	Kinfauns.		Moncrieffe.		Ten Years.	Kinfauns.		Moncrieffe.	
	Salmon.	Grilse.	Salmon.	Grilse.		Salmon.	Grilse.	Salmon.	Grilse.		Salmon.	Grilse.	Salmon.	Grilse.
1788	5,773	1,538	2,827	697	1801	6,635	3,061	2,916	1,537	1815	8,239	7,674	2,280	2,755
1789	9,996	1,083	2,036	364	1802	7,037	1,141	3,081	483	1816	10,811	12,746	2,214	2,388
1790	6,635	1,829	2,488	531	1803	4,208	887	1,925	795	1817	15,056	7,719	3,439	1,504
1791	8,639	1,320	1,614	258	1804	4,051	3,219	1,351	1,282	1818	10,080	7,026	2,224	1,791
1792	15,242	2,203	1,667	315	1805	5,458	1,258	3,808	604	1819	10,743	12,220	2,761	2,870
1793	7,836	2,155	1,717	548	1806	4,072	1,242	1,928	616	1820	6,328	10,780	1,901	4,009
1794	9,924	1,549	2,809	850	1807	5,306	2,209	1,662	966	1821	9,879	6,310	2,445	2,019
1795	9,392	2,320	2,017	922	1808	3,371	1,132	880	668	1822	6,435	4,638	2,061	2,133
1796	6,285	441	2,740	145	1809	3,393	1,072	1,190	518	1823	4,998	7,317	1,268	2,052
1797	7,451	2,699	1,599	337	1810	3,132	947	1,608	663	1824	7,536	10,461	2,470	3,601
Total ..	87,203	17,140	21,544	4,967		46,663	16,168	20,349	8,132		90,105	87,091	23,063	25,113
Average	8,720 3/10	1,714	2,154 4/10	496 7/10		4,666 3/10	1,616 8/10	2,034 9/10	813 2/10		9,010 5/10	8,709 1/10	2,306 3/10	2,511 3/10

The following affords the means of comparing these same fishings for ten years before and ten years after certain artificial alterations had been made in the bed of the river Tay.

Before Perth Navigation Bill.[2]					After Perth Navigation Bill.				
Ten Years.	Kinfauns.		Moncrieffe.		Ten Years.	Kinfauns.		Moncrieffe.	
	Salmon.	Grilse.	Salmon.	Grilse.		Salmon.	Grilse.	Salmon.	Grilse.
1825	7,005	12,774	1,805	4,384	1836	7,668	8,179	2,276	2,549
1826	3.500	7,000	1,814	2,544	1837	5,352	12,641	1,642	3,450
1827	2,629	6,078	1,239	2,650	1838	5,523	9,639	1,494	2,541
1828	4,721	12,342	2,272	5,297	1839	7,379	6,686	1,871	1,384
1829	5,566	7,853	2,726	3,773	1840	3,735	9,215	969	1,963
1830	5,828	10,605	2,349	3,391	1841	7,757	12,398	1,772	2,076
1831	3,218	6,836	1,748	3,523	1842	7,305	21,153	1,489	4,023
1832	5,292	9,822	2,388	3,934	1843	9,847	11,353	1,861	2,363
1833	3,672	9,016	1,291	2,778	1844	7,772	7,775	2,114	1,658
1834	5,960	10,196	2,128	3,392	1845	4,991	10,269	1,082	2,031
Total .	47,391	92,522	19,760	35,666		69,329	109,308	16,570	24,038
Average	4,739 1/10	9,252 2/10	1,976	3,566 6/10		6,932 9/10	10,930 8/10	1,657	2,404

The most remarkable feature in the former of these tables is the great preponderance which its early periods exhibit of salmon over grilse. We cannot easily account for this disparity upon any natural principle, and have sometimes thought it must have arisen from the nets used in earlier times being larger in the mesh than now, and so admitting of many of the least-grown grilse making their way through the cordage. This escape would tell in two respects, as diminishing the amount of captured grilse of that year, and adding to the number of adult salmon during the one which followed; and this effect would continue to be produced each successive season. However, we have failed to ascertain the fact, that any change or restriction in the dimension of the meshes took place in the Tay so recently as the year 1823. It will be observed from the table, that grilse preponderate during two or three prior seasons—those of 1816, 1819, 1820,—and fall off again for a couple of years; but that after that they greatly increase,

[1] *Report of the Select Committee on the Irish Fisheries*, p. 8. (1849.)

[2] The Perth Navigation Bill, above referred to, is an act of parliament passed with a view to the improvement of the river Tay, so as to admit of easier access from the sea to the "Fair City."

Salmon-fisheries of the Tay.

and keep the lead apparently to the close, with the exception of the seasons of 1839 and 1844.[1]

Although the young of all animals are naturally more numerous than their parents, it is not necessarily so as respects the proportion between grilse and salmon. Young salmon, including their various adolescent stages, are doubtless more abundant than old ones; but as concerns simply *grilse*, it must be borne in mind that these are all the produce of one season, and represent only a single summer of the salmon life, whereas salmon, properly so called, are the congregated or abiding produce of several years. A grilse, whether he lives or dies, can exist, as such, for only a portion of a single season. If he is captured, and sent to market, his days are ended; if he escapes till the ensuing summer, he is converted, by a law of his nature, and whether he will or no, into a salmon. So in either case he must cease to be a grilse. The later of the Tweed returns show that of the whole of the salmon kind captured, including young and old, *four-fifths* are killed on their first ascent from the sea, and consequently before they have become parents, or added to their kind. The severity of fishing now practised decreases the average duration of salmon life. The result of this is, that the fish are not only fewer in number, but smaller in size. The reason that so many forty-pound salmon were found by our anglers in Norway is, that they were old fish in a new field. Far fewer of that size now occur there, because the veterans have been killed out, and the increase of sportsmen has become so great and continuous, that the fish have no sufficient time to grow. The same causes, multiplied a thousand-fold, affect our fish at home. The small proportion that escape from year to year must be a wonder to themselves. To pass from the sea to the far shallows where the spawning-places lie, as many dangers must be successfully surmounted as those which beset our troops between Cabul and Jellalabad. We believe that only a single man ever gained the fortress. Had the conditions of his life required that he must, under a constant continuance of the same perils, have gone back to Cabul, and then rejourneyed to Jellalabad, and so on every season in succession, we could scarcely marvel at his not becoming an old man. A very large salmon must be rather an elderly one, but as no salmon now dies a natural death, and almost all are cut off in the very blossom of their days, it is easy to see how their dimensions have decreased. It is many years since Mr Hogarth (at one period the greatest lessee of salmon-fisheries in Britain) gave his opinion that over-fishing had diminished their size as well as number. "We now seldom see a salmon above two years old." The weight of fish, from the undue prevalence of the imaginative faculty among the sons of men, is frequently exaggerated, especially by the votaries of the rod and line. This inaccuracy seems sometimes to obtain even among the working people of the commercial fisheries. When the celebrated "Rob Kerse of the Trows" (on the Tweed, at Makerstoun) was asked, somewhat upbraidingly, how it happened on a certain occasion that those above him were catching larger fish than himself, he replied, "It's no that the're gettin' ony bigger fish than us up yonder, only the folk themsel's are far bigger leears."

We have no note of the produce of the Tay since the season of 1844, but the following *Rentals* will show the money value of these fisheries for the last 30 years.

Rental of Fishings in the River Tay, from Perth to Newburgh, for the seasons from 1825 *to* 1855, *both inclusive.*

Proprietors.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.
	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.
Lord Gray	4000	3800	4000	4000	4000	3600	4000	2000	2500	2700	2700	2700	2700	2700	3000	3000
City of Perth	1100	1300	1300	1300	1300	1300	1305	1305	1305	1305	1305	824	824	824	1000	1000
Sir J. Richardson of Pitfour.	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1500	1500	1500	1500	1500	1475
Sir Thomas Moncrieffe	800	1000	1000	1000	1000	1000	1000	1000	800	800	800	800	800	800	800	800
Inchyra Fishings	600	600	600	600	600	400	400	355	355	355	386	386	386	386	386	650
Earl of Wemyss	270	270	350	350	500	500	500	500	500	340	490	490	490	490	490	600
Mr Hay of Seggieden	160	160	180	180	180	180	180	185	185	220	195	195	210	210	210	95
Mr Hay of Mugdrum	130	180	180	180	180	180	180	120	120	100	100	100	110	120	167	167
Mr Patterson of Carpou	250	250	250	300	330	300	330	295	295	295	210	210	210	287	288	288
Mr Allan of Errol	199	199	175	123	123	123	102	102	102	95	91	91	95	101	101	101
Total	8509	8759	8735	9033	9183	8283	8967	6862	7162	7210	7775	7296	7325	7418	7942	8176

Proprietors.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.
	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.	L.
Lord Gray	3000	3000	3000	3200	3000	3000	3000	3000	3000	2293	2018	1600	1800	2100	2100
City of Perth	1000	1000	1000	1000	1000	1000	1055	1055	1055	1000	1023	822	822	822	822
Sir J. Richardson of Pitfour	1475	1050	1150	980	757	757	1030	1055	1055	878	932	642	647	648	1014
Sir Thomas Moncrieffe	800	800	800	800	800	400	550	550	550	450	450	225	250	250	250
Inchyra Fishings	650	650	660	660	660	660	915	915	915	625	610	595	700	700	700
Earl of Wemyss	500	550	550	550	1369	1369	1369	1802	1802	1436	1590	1213	1607	1818	1727
Mr Hay of Seggieden	305	370	370	370	381	381	381	577	577	380	500	440	490	430	500
Mr Hay of Mugdrum	167	190	190	190	190	190	371	377	382	346	352	293	421	643	686
Mr Patterson of Carpou	121	73	73	73	73	73	50	50	50	50	51	80	84	140	161
Mr Allan of Erroll	101	101	260	236	212	180	318	337	297	253	287	188	231	211	457
Total	8119	7784	8053	8059	8442	8010	9039	9718	9683	7711	7813	6098	6962	7762	8417

The preceding table shows no great variation in the total value of these fisheries during the last thirty years; the produce of 1825 being L.8509, and of 1855 L.8417, with a decline in 1852 to L.6098. But individual properties will be seen to exhibit a wide range in both directions. Thus the fishings of Lord Gray and Sir Thomas Moncrieffe have fallen off, while those of Lord Wemyss, Mr Hay of Mugdrum, and Mr Allan of Errol, have largely increased.

Our next table presents a complete exposition of the captures in the Tay, and its tributary the Earn, for a period of fifteen years.

[1] We have made a calculation from the foregoing tables, that during the three given periods of ten years prior to 1824, there was a total take,—of salmon 352,955, of grilse only 158,611; while during the two periods of ten years between 1825 and 1845 the take was, of salmon 152,950, of grilse 261,535, the proportions being thus reversed.

Table of the Salmon and Grilse caught in the Rivers Tay and Earn, commencing with the season of 1830, *and ending with that of* 1844.

Proprietors.	1830.		1831.		1832.		1833.		1834.		1835.		1836.		1837.	
	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.
Lady Keith	32	33	32	33	32	33	32	33	32	33	19	24	84	15	75	74
Lord Willoughby	679	1,136	262	301	235	338	295	380	370	372	202	365	598	445	422	522
Lord Dunmore	596	913	242	208	196	113	345	399	347	360	717	567	429	329	155	237
Mr Richardson, Ballathy	246	429	160	180	160	180	160	180	160	180	140	160	220	180	195	408
Duke of Athol	189	152	90	50	51	...	90	50	90	50	200	166	143	75	152	152
Stanley Company	113	33	56	22	29	10	33	...	82	34	63	21	85	35	57	15
Lord Lyndoch	590	1,422	204	188	245	169	218	318	150	120	187	348	207	302	227	348
Lord Mansfield	999	1,608	448	235	476	450	300	100	594	487	514	460	506	494	400	396
Lord Kinnoull	1,277	2,052	510	594	694	632	477	713	742	774	690	1,171	659	540	421	684
Sir Thomas Moncrieffe	2,349	3,391	1,748	3,523	2,388	3,934	1,291	2,778	2,128	3,892	2,557	5,357	2,276	2,549	1,642	3,450
City of Perth	3,603	7,790	2,126	5,236	2,625	5,269	1,796	4,842	2,522	4,518	2,583	5,381	2,934	3,478	2,525	5,301
Lord Gray	5,828	10,605	3,218	6,836	5,292	9,822	3,672	9,016	5,960	10,196	7,591	13,876	7,668	8,179	5,352	12,641
Mr Hay of Seggieden	588	938	231	494	588	974	356	1,071	604	1,233	832	2,136	714	975	577	1,461
Lord Wemyss	841	1,681	1,014	3,174	1,137	3,201	656	2,591	1,390	2,939	1,253	2,582	791	1,364	1,348	5,202
Mr Cristal of Inchyra	1,038	1,966	603	1,420	942	2,186	1,118	2,726	1,448	2,379	2,147	4,623	1,775	2,415	1,814	4,170
Mr Paterson of Carpou	271	793	450	1,210	711	2,110	458	1,295	454	976	783	1,819	565	874	495	1,380
Sir J. Richardson	2,875	5,813	2,186	4,794	3,749	8,995	2,118	6,307	3,775	7,639	40	9,463	2,998	3,809	1,747	7,300
Mr Hay of Leys	340	1,194	293	721	430	1,910	217	847	317	809	...	2,001	447	771	481	1,606
Miss Yeaman of Muir	210	337	15	71	356	1,075	78	163	83	233	148	376	73	100	154	520
Mr Allan of Errol	232	816	336	890	508	1,848	414	996	390	726	217	335	389	817	784	1,392
Lord Dundas	211	666	266	758	960	2,499	381	996	533	1,390	1,117	1,275	175	301	209	401
Hon. Mr Stuart	46	106	91	178	68	236	88	327	134	416	173	199	22	27	26	43
Mr Wedderburn	208	575	343	781	371	846	354	990	490	1,190	527	543	105	192	189	384
Mrs Morrison of Naughton	79	277	155	369	175	492	155	520	209	537	175	183	113	213	231	529
Mr Stewart, St Fort	230	367	343	412	329	581	271	640	294	500	182	196	63	80	142	327
Lord Douglass	Not fished.	...	...	...	...	...	...	...	...	...	...	...	14	5	Not fished.	...
Town of Dundee	300	671	225	307	424	566	602	1,708	847	1,059	831	1,104	373	479	425	666
General Hunter	102	130	241	350	82	108	184	306	190	246	86	108	81	94	77	177
Colonel Fotheringham	264	474	489	876	202	243	583	1,580	620	430	480	590	290	406	383	491
Mr Kier of Grange	272	872	116	435	101	108	163	472	163	472	163	472	51	32	83	72
Mr Hunter of Blackness	114	204	168	204	70	128	101	152	132	158	132	146	17	15	73	116
Mr Dalgleish of Scotscraig	1,037	1,680	1,574	2,067	1,071	1,874	2,087	5,378	1,516	2,007	2,429	3,547	1,760	2,170	1,293	2,627
Lord Panmure	1,884	4,073	1,530	1,731	1,121	1,997	1,418	2,591	1,089	1,140	898	1,172	998	812	650	850
Mr Hunter of Seaside	15	52	62	106	80	158	45	147	190	474	78	187	Not	fished.	67	125
Total of each year	27,658	53,249	19,827	38,754	25,898	53,085	20,556	50,612	28,045	47,469	32,964	60,953	27,623	32,572	23,871	54,069

Proprietors.	1838.		1839.		1840.		1841.		1842.		1843.		1844.	
	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.	Sal.	Gril.
Lady Keith	40	46	44	40	24	48	28	40	11	12	681	395	50	50
Lord Willoughby	445	646	306	200	170	149	349	325	365	622			343	86
Lord Dunmore	189	293	175	223	115	146	245	400	321	659	341	345	178	118
Mr Richardson, Ballathy	110	219	118	44	56	163	162	187	195	656	307	321	115	104
Duke of Athol	134	125	151	60	32	43	70	83	95	99	120	100	85	50
Stanley Company	29	5	59	27	23	12	25	21	71	30	89	16	55	9
Lord Lyndoch	245	573	220	309	128	405	288	564	234	719	310	638	180	176
Lord Mansfield	468	499	580	445	234	377	333	305	484	761	533	390	339	250
Lord Kinnoull	457	489	484	254	464	826	570	892	534	1,039	655	688	517	487
Sir Thomas Moncrieffe	1,494	2,541	1,871	1,384	969	1,963	1,772	2,076	1,489	4,023	1,861	2,363	2,114	1,658
City of Perth	2,298	4,376	2,415	2,086	1,223	3,197	2,333	3,761	2,973	8,370	4,251	4,813	3,411	2,922
Lord Gray	5,523	9,639	7,379	6,686	3,735	9,215	7,757	12,398	7,305	21,153	9,847	11,475	7,772	7,775
Mr Hay of Seggieden	550	1,117	228	219	345	757	853	1,325	905	1,776	908	852	719	681
Lord Wemyss	1,165	2,479	1,752	1,900	411	1,526	1,329	2,732	1,704	9,278	2,760	5,607	3,336	4,079
Mr Cristal of Inchyra	1,802	3,449	1,686	1,719	1,053	2,293	1,617	3,051	1,891	7,259	2,876	4,143	2,458	3,276
Mr Paterson of Carpou	395	928	367	406	196	646	456	967	205	776	408	658	502	581
Sir J. Richardson	1,810	3,532	2,614	2,464	1,784	4,690	2,611	4,686	3,328	10,378	3,511	3,676	3,076	2,707
Mr Hay of Leys	317	830	457	561	212	690	447	842	992	4,059	1,479	2,165	1,643	1,964
Miss Yeaman of Muir	285	396	72	84	75	167	41	72	150	520	305	391	189	242
Mr Allan of Errol	142	300	428	486	322	479	418	622	632	1,628	800	1,042	733	792
Lord Dundas	131	543	146	153	92	256	150	331	272	732	300	500	350	410
Hon. Mr Stuart	85	253	85	253	16	27	47	121	36	195	60	72	50	110
Mr Wedderburn	130	434	114	96	45	128	228	252	203	698	180	200	160	210
Mrs Morrison of Naughton	184	550	90	149	37	175	102	164	55	170	84	116	163	215
Mr Stewart, St Fort	161	490	94	64	33	76	100	230	61	246	112	160	120	160
Lord Douglass	...	...	...	...	...	...	...	...	...	...	24	13	30	22
Town of Dundee	218	698	169	73	80	152	103	154	239	568	275	500	255	276
General Hunter	32	108	29	25	16	50	47	91	47	91	47	91	Not fished.	...
Colonel Fotheringham	418	1,119	177	112	136	304	268	297	222	414	185	174	206	138
Mr Keir of Grange	74	95	71	82	27	29	67	109	58	52	64	59	88	95
Mr Hunter of Blackness	1,422	3,699	933	639	343	692	845	1,446	903	1,874	908	884	1,203	1,070
Mr Dalgleish of Scotscraig	52	115	70	61	...	...	46	62	57	111	44	37	34	15
Lord Panmure	582	1,147	596	415	204	343	605	817	632	1,367	688	547	584	374
Mr Hunter of Seaside	105	203	13	35	50	150	62	140	110	204	115	152	151	251
Total of each year	21,492	41,936	23,981	21,754	12,650	30.162	24,373	39,563	26,779	80,539	35,126	43,617	31,213	31,353

Salmon-fisheries of the Tweed.

It will be seen from the preceding table that the captures frequently vary considerably from year to year, but that on the whole there has been no diminution. In fact, the total of the last three years is greater by nearly 5000 fish than that of the first three. The best year was 1842, the next best 1835. The worst year for grilse was 1839, the worst for salmon 1840.

We shall now exhibit the produce of the Tweed (one of the greatest of the salmon rivers of our country) for the preceding forty-four years. It includes only the commercial fisheries, which are those of its lower districts, and excludes all captures by the rod and the nefarious leister.

Calculated Produce of the river Tweed as transmitted from Berwick.

Average for five Years.	Salmon.	Grilse.	Trout.
1811 to 1815	40,297	68,057	31,235
1816 to 1820	37,938	87,089	48,078
1821 to 1825	22,930	57,647	62,475
1826	12,040	85,378	59,203
1827	10,725	54,034	43,441
1828	13,511	39 248	39,563
1829	5,350	34,773	64,630
1830	7,415	66,520	37,486
Average for five years	9.804	53,990	48,864
1831	13,197	43,244	77,037
1832	9,709	41,411	77,308
1833	10,428	93,939	60,178
1834	16,106	59,262	48,852
1835	22,642	87,707	82,229
Average for five years	14,416	65,112	69,121
1836	16,957	34,864	63,616
1837	14,577	60,429	57,426
1838	12,785	78,577	40,876
1839	15,508	35,449	56,124
1840	10,920	52,117	56,342
Average for five years	14,149	52,283	54,877
1841	16,464	71,254	64,672
1842	19,198	109,935	76,071
1843	17,777	66,293	54,209
1844	21,830	88,003	99,256
1845	18,962	69,752	54,355
Average for five years	18,846	81,047	69,712
1846	17,878	37,506	38,679
1847	9,032	53,075	67,796
1848	9,478	97,102	52,541
1849	11,484	59,405	39,435
1850	9,522	33,864	49,701
Average for five years	11,479	56,190	49,630
1851	8,789	16,855	45,326
1852	5,808	28,902	24,773
1853	9,199	43,075	37,341
1854	15,299	16,739	32,645
Average for four years	9,774	26,393	35,021

It will be seen from the preceding columns that the Tweed, although with periods of resuscitation, is suffering from symptoms of a deep decline. The greatest year in our record for salmon is that of 1814; the most remarkable for grilse that of 1816. More recently, 1842 was a very productive season for grilse, and that of 1844 was a good one for salmon. These and the adjoining years being favourable, the quinquennial average, as taken in 1845, mounted up. But since 1846 there has been a sudden and large decline, especially of salmon (1848 was great in grilse); although in 1854 salmon rose in number, while grilse fell. It will be seen that the supply of sea-trout is also going down.

Salmon-fisheries of the Tweed.

	Salmon.	Grilse.	Trout.
The totals of our first five years are	201,484	340,285	156,176
The totals of our last five years are	48,617	139,435	189,786
	Decrease, 151,867	Decrease, 210,850	Increase, 33,610

We entertained some hope, from the apparent improvement, at least of salmon, in 1854, that the current season might have turned out a good one. We regret to learn, however, that this is not the case.[1]

In regard to the *rental* of the Tweed, it may be observed that it does not vary in the same way as the produce, as much depends upon the length of existing leases, the prices at which the fish happen to sell for, and a good deal upon the profit and loss account of the tenants, who in some seasons may have a considerable gain, and in others a heavy reverse. For the present year of 1855, it is believed that (unless a very favourable change takes place before the close) not one shilling will be gained by any fishing in the Tweed, and the tenants will consequently have to bear the loss; while the rental, as assessed for taxes, will probably appear not much less than that of the preceding year. At the same time the rent must always in some degree be regulated by the state of the fishing, and the following is the amount at which the Tweed tax has been assessed during the last nine years for all the salmon-fishings in the lower district of the river, which extends from Eden-mouth to the sea:—

For the Year		For the Year	
1846	L.5358 2 0	1851	L.5098 0 10
1847	5435 19 6	1852	4682 10 6
1848	5054 10 7	1853	4561 11 6
1849	5214 1 0	1854	4302 1 6[2]
1850	5051 12 6		

We have taken some pains to ascertain the average value of salmon, which, however, we have found it by no means easy to do, in as far as both the weight of the fish and the prices vary much in different seasons; and, therefore, to arrive at anything like an exact idea of the money value, the weights and prices for each season would require to be taken separately. Mr Paulin informs us that, taking a general view, the Tweed salmon will average from 11 to 12 pounds, the grilse about 6 or 6½ pounds, and the sea-trout from 4 to 5 pounds. Among the latter there is often a pretty large supply of whitlings, which are the younger fish, and which reach about 2 or 2½ pounds each. In the earlier part of the season the Tweed salmon do not average above 8 pounds, but before the end of the season they will weigh above 14 pounds. The following is a note of the

[1] In a communication with which we have been favoured by Mr Paulin of Berwick-upon-Tweed, from whom we received the above statement, he remarks as follows:—"You will observe that the tendency is still downwards, especially with grilse; and I regret to say, that, so far as this season has gone, salmon are not more than one-third of what they were last year—grilse are considerably short of what they were last year, although it was the worst upon record—and trouts are not much above one-half; so that this season has all the appearance of turning out to be the very worst ever known. This is something very unaccountable; for from the extended protection that has been afforded to the Tweed for these four or five years past, and the great expense incurred in keeping up a large police force, it might have been expected that the numbers of salmon, grilse, and trout would have all increased, which is quite the reverse, and almost makes one think that there must be some natural law in operation affecting the breed of salmon other than is generally supposed."—*7th August* 1855.

[2] Mr Paulin adds:—"You will see from the above that the rental of the Tweed has fallen off considerably of late years, and I have no doubt but it will continue to go lower yet, as I have every reason to believe that even the above sums have not been realised as rent from the balance of the produce less the working expenses, for several years past."

Salmon-fisheries of the Tweed.

average value (wholesale prices, we presume) at Berwick for three years:—

	Salmon.			Grilse.			Trout.		
In 1847......	L.0	7	10	L.0	2	2½	L.0	1	2
1848......	0	8	10¾	0	2	1¾	0	1	1½
1849......	0	8	3¾	0	10	7⅞	0	1	0⅝
Average of three years	L.0	8	4⅛	L.0	2	1	L.0	1	1⅜

We are unable to give the exact rental of all the fisheries on the Tweed, but as concerns the lower portions, that is, from the mouth to about 20 miles upwards, we may state the following facts. In 1814, the rent was L.20,000; in 1823, L.10,000; and for seven years preceding that, the average was L.12,000. In 1831 the assessment was upon L.4691; in 1838 it had fallen as low as L.3759, after which it gradually rose again till the recent fall in 1852. As a trading speculation, salmon-fishing may be regarded as precarious, and seldom in the long-run successful. The hope of a successful year, from natural causes, is indulged in, and sometimes gratified, but the profession is an adventurous one, and subject to great mischances. It is understood that frequent losses are incurred by the lessees of fisheries both in Tweed and Tay. But let us hope that the expenses are often more than paid by a successful catch and good markets during the earlier portions of the season, and then, as fish require no feeding, and come uncalled for from the "vasty deep," whatever afterwards enters the net may realize Franklin's phrase, "a bit of silver pulled out of the water." A beautiful and sumptuous bit it often seems to be, although to the angler's eye of brief presentment—"a moment white, then gone for ever."

We may state that there are no fixed nets of any kind allowed within five miles of either side of Tweed-mouth. They are prohibited by an act passed in 1830. But that salmon course, or *run*, as it is termed, along the sea-shore, instead of entering rivers directly from the open sea, is shown both in a general way by the success of bag-nets along our eastern coasts, often in places remote from rivers, but more specially by certain stations near the above five-mile boundary. The number of salmon and grilse captured at a station with two small clusters of nets, occupying only a few yards of beach, and near no flow of fresh water, or indentation of the coast, averaged during the last four or five years preceding 1851, nearly one-half of the whole number taken in the Tweed.

In considering the deficiencies of our salmon rivers, we must bear in mind this increased supply of sea-salmon from our outer shores, and the general fact that no animal killed in one place can be captured in another. The decline during recent years of the salmon-fisheries in so many of our estuaries and the mouths of rivers, may, we doubt not, be attributed to various causes, of which, however, the great increase of stake and bag nets, is the chief. The greater cheapness of salmon in earlier times, so often quoted in proof of its former abundance, must be considered in connection with a much smaller population, a deficiency in the means of transport, and entire ignorance of any plan of preservation by ice. We have been told that the practice of sending Scotch salmon to the London markets packed in ice was introduced by the late George Dempster, Esq. of Dunichen. This, of course, raised the price of fish, and gave a great stimulus to an increased capture. Too many can scarcely now be be taken at a time, seeing that a well-known method is at hand for their at least temporary preservation. In former times all redundant salmon were salted, and this indeed became so regular a trade, that 1000 barrels have been annually preserved and exported from certain stations, the entire produce of which would not now equal one-half of that amount.[1] The salting vats were soon filled, and the fishing ended so early, that grilse, which arrived later, were deemed of little consequence. Of course the upper portions of such rivers as had a good run of water were well supplied with both early and breeding fish, and thus anglers, and all others, whether legal or illegitimate, had ample sport, without interfering with futurity.

Supposed causes of deterioration.

The increase of land-drainage, especially of the open sheep drains of the pastoral districts, is supposed to have proved injurious, by bringing the surface water more rapidly, and in greater volume, into the river, and hastening its descent into the sea. Salmon prefer travelling upwards when the river water is neither muddy and uproarious on the one hand, nor too low and limpid on the other. They prefer it full but clear, that is, by no means clayey. But these required natural conditions are now less easily obtained than formerly, in consequence of man's artificial labours in the improvement of the land. These sudden floods also alter the character and structure of the spawning beds by shifting the gravel, or destroy them altogether after the parent fish have performed their duties to posterity. Many of the more lowland streams are deteriorated in their nature by the increase of human settlements along their banks, and the consequent increase of various manufacturing works, the operations of which produce refuse, abhorrent to the tastes of salmon. Suppose one of these fish about to leave the translucent basin of the Firth of Clyde, and desirous to enter what he considers as a tranquil change into pure sweet water. He first shows himself

[1] It appears from the accounts of stores of provisions for the religious houses given in Dugdale's *Monasticon*, that salted fish, especially salmon, were in large request as winter food. It may be inferred that a great mass of private persons were dependent on a like supply. Even armies could not be marched without their cured fish. We have in Rymer's *Fœdera* an order by Edward the Second to provide 3000 dried salmon for the sustenance of his men; and Monstrelet, when mentioning the defeat of the English, and the capture of their army, adds, "Que grande partie du charoy des dits Anglois etoient chargés de harenc, et à cette cause la battaile fut appellé *la battaile des harencs*." All wild animals diminish in amount as the surrounding tribes of the human race increase in number and civilization. We all know how bountiful is the supply of salmon, or fish of the salmon kind, in the dreary northern regions. So abundant are they at the mouths of certain rivers of Boothia Felix that 3378 were obtained at a single haul. They varied in weight from 2 to 14 pounds, and exceeded in the aggregate 6 tons. This was *Salmo Rossii* of Richardson. Sir George Simpson found salmon so plentiful in the Columbia river, that as many as 1000 per day, some of them weighing above 40 pounds, have been captured in a basket. In a little stream in New Archangel (Russian America), within a mile of the fort, so numerous are salmon, that when ascending the stream they have been literally known to embarass the movements of a canoe. About 100,000 are salted annually for the use of the fort.

Mr Erman tells us (*Travels in Siberia*) that the Russian traders annually fit out great fishing expeditions to the Obi, and settle themselves in the neighbourhood of the most productive sand-banks, which they purchase or hire from the Ostyak inhabitants. The nets used are 800 feet in length. The salmon are salted and packed in tubs, which contain from 800 to 2500 fish each. Some of these Russian companies are said to have recently realized a profit of 150,000 rubles (about L.25,000) in a single summer. "But," adds Mr Erman, "it is at the same time equally certain that the fisheries of the Ostyaks round about were thereby seriously damaged." The Russian official agents, to whom the superintendence of the country is confided, have always been perplexed by the difficulty of reconciling the conflicting interests of the case. M. Kamiloff has proposed a felicitously characteristic expedient to his government, that it should take into its own entire and immediate possession all these valuable fisheries on the Obi, and lease them only to Russians, "for then," he observes, "the harmless and amiable Ostyaks, to whom the sand-banks belong by inheritance, would at once and for ever be relieved from the anxiety of retaining possession of them, and nothing more would be heard of their troublesome complaints of local injuries done to them. The fish-eating inhabitants might then learn to support themselves on the nuts of the Siberian pine (fir tops!), or by catching birds and quadrupeds; so engaged they would not be troubled with competitors, and might enjoy tranquillity of mind!!"

Supposed causes of deterioration.

near Dumbarton like a wedge of lustrous silver, with deep cerulean back, and breast like that of leper, white as snow. He passes upwards, and finds himself in the course of the first night at the Broomielaw, or other now not very rural portion of the river, in the midst of many ships, in the immediate vicinity of 11,965 inhabited houses, and surrounded by a population of 329,097 men, women, and children—his own actual object being to seek some solitary stainless pool, reflecting a lichen-coloured rock or emerald bank, and dappled with many a golden light playing as with living lustre over the beautiful mosaic of its pebbly floor. We cannot wonder that after losing sight of his fair partner in that turbid stream, he should turn tail with disgust, and revisit the mouth of the Molendinar burn no more for ever.

The destruction of fish about to spawn during close time is another alleged cause of the decrease of salmon. Of course a fish killed before it spawns will never voluntarily spawn afterwards, but we doubt not that great destruction of this sort took place likewise in bygone days, and that it is not a new evil under the sun, although the more it is now prevented the better for the future fry. It has been argued that a considerable extension of the period of angling after the commercial close would be beneficial, by enabling the legitimate sportsman to check or overawe the illegitimate poacher. "When we look at the circumstances and the localities in which salmon are bred, and those in which they are killed, the wonder seems to be, not that the supply of this noble fish should be so rapidly diminishing and deteriorating, as that even its immense natural powers of reproduction should have hitherto been able to prevent its absolute extinction. The seed is sown above, and the harvest is reaped below. Those who sow do not reap, and those who reap do not sow,—what, then, more natural than that both processes should be ill performed? There is too little sowing and too much reaping. Those in whose waters the seed is sown say, 'The fish are never allowed to reach us till the law prohibits us from killing them; why should we incur trouble and expense, and offence, for the benefit of the very people who do their utmost to intercept what nature sends us?—let the poachers work their will.' Those who reap say, 'The people above will take no care of these fish; let us by all means capture all we can, careless of the future,—it will last our time,' that being seldom so much as a five-years' lease. And so, between these two operations—a careless and wasteful seedtime, and a rigorous reaping and gleaning—the crops are becoming poorer and poorer, and the harvest-grounds hastening to absolute sterility."[1] There is no doubt that if some accommodating arrangement were entered into, by which more favour should be shown to the upper heritors, resident proprietors, and the higher class of farmers in those uplands, would do much more among their people to check all illegal and nocturnal malpractices in the way of burning and leistering, than however large a squad of hired bailiffs have it in their power to do. The present mode of prevention is not only precarious but expensive—the proprietors of some fisheries paying about 20 per cent. of their rental for that object alone. We hope it may be felt as a check upon the over-fishing with nets before referred to, that it is now beginning to tell along the sea-shore, as well as in the estuaries, at the mouths of rivers, and up the streams and tributaries. It may again be found, as it was once of old, to be but a short-sighted policy to kill the goose that laid the golden eggs.

Supposed causes of deterioration.

But it is evident that when the seaward salmon-fisheries were unknown or neglected, those in the higher stations must have been necessarily in a more flourishing condition. The fisheries on the Tay above Perth bridge produced 11,500 fish in the year 1792, 10,400 in 1795, and never less than 5000 in any one year up to that of 1800. Their *take* in 1850 was reduced to about 1500, and may possibly be decreasing from year to year. This is in no way owing to fewer fish being bred above than formerly, but to far more being captured below. The lower fisheries of the river and tideway have increased in number and activity, and must be worked hard to keep up a remunerating produce, while the owners make a corresponding complaint that the sea-shore fisheries intercept so large a portion of what was in use to ascend their way. In salmon-fisheries, as possibly in several other things, the terms *productive* and *destructive* are relative, and even convertible. A successful stake-net fishery is regarded by its proprietor as very productive, while it is viewed as destructive, exactly in the same proportion, by the owners of more inland stations. There are now as many fish bred as ever, but that they are killed at an earlier age is evident from our tabular views, in which it will be seen how greatly the slaughter of grilse now exceeds that of salmon. But so long as the shore fisheries are worked only by those who have the legal right to do so, the other proprietors can scarcely complain that a new field has been opened by others, which may reduce or equalize their own previously exclusive gains. Of course all that the pensive public desires is a fair field and no favour, in the hope that a larger supply, at a lower price, may accrue to itself.

Mr James Bell, a lessee in former days of salmon in the Tay and Tweed to the amount of L.9200 a-year, stated in evidence before the Select Committee of the House of Commons (1824), that salmon taken in the stake-nets were often inferior to those secured by net and coble, because, unless removed before low tide, the water receded, and left the fish "floundering about, heated, and dying." It is no doubt quite possible to convert, in the lapse of no long time, a good stake-net salmon into a bad one, but the folly of the owner would be more surprising than the state of the fish. Mr J. Crawford, who had been long engaged in the Waterford salmon-trade, gave his opinion to the Select Committee of 1849, that as good a sale could not be made of salmon caught by the fishermen with cots (small boats) and nets as of what were taken by the weir, as, by plunging about in the nets, they are apt to knock their scales off, and injure their aspect and condition. He, moreover, mentioned, in regard to the difference of value between a salmon caught in the sea or in fresh water, that the London salesmen give fourpence a-pound more for a tide-water fish, caught near the mouth of a river; that fish going up, and remaining above three weeks out of the tide-water, into fresh water, become "gray" and of a gluey nature, and that salesmen mark in their account the number of gray fish at 4d. per lb. less than what they pay for the tide-water take. However much people may vie with each other, and even vary their views to suit a change in their own position, we consider no fact in the posthumous history of a salmon more firmly established than this, that the nearer the sea the better the fish. "A salt-water salmon," says Mr Brabazon, "is far superior to one that has been even a short time in river water, the flesh is a better colour, with a large flake of curd between each flake of fish, which is both firm and rich."[2]

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[1] *Edinburgh Review*, vol. xciii., p. 358.

[2] We have sometimes fancied that even a few hours in river water made a difference in the flavour of salmon. Among other fisheries of his grace the Duke of Sutherland, there is one at Loch Inver, a small sea bay upon the north-west coast, into which the river Inver is discharged at once without any intervening estuary. The salmon are caught with a scringe-net near the mouth, but still in salt water, and about a mile upwards fish of the same tide are captured in a cruive. Both kinds may be tasted at the same meal, and our impression was that the difference was at least perceptible in the slightly fresh-water flavour (so manifest in trouts) of such as were taken from the cruive. Yet an entirely different opinion seems to be entertained by others of greater experience than ourselves. The late Mr

Supposed causes of deterioration.

As the public is beneficially served by stake-nets, and their erection is legal in sea-firths and on open coasts, it would be in vain to complain that they injure the upper fisheries. No salmon can be caught and killed twice over, and the opposing interests cannot be easily reconciled. When up an estuary, or near a river's mouth, there is no doubt that the injury is direct and demonstrable. Mr Buist has shown, from the books of the Dundee Shipping Company, by whom the almost entire produce of the Tay was in former times despatched to London, that during the last three years of the stake-net operations in that estuary (1810, 1811, 1812) the average annual export from the river fishings was only 1665 boxes; while the stake-net fishers exported 4000 boxes—making together 5665 boxes yearly. But during the first three years after the stake-nets were removed, the average yearly product of the river fisheries rose to 4552 boxes, while during the next three years, when the recovery of the river was completed, it amounted to 5930 boxes, being for that later period 265 boxes a-year beyond the product of both fisheries while the stake-nets were in operation. Of course the alteration in the individual fishings and their rents was conformable. Lord Gray's portion of the river, which during the stake-net practice produced in two years only 8534 grilse and salmon, yielded in the same period after the removal of the nets 46,332 of these fishes. The rent, which during the former period had fallen to L.1205, immediately rose to L.4000; and that of the whole river fisheries from L.5101 to L.12,005.

In other estuaries, of course, similar causes produce the same effects. Mr John Stevenson stated to the Committee of the House of Commons, that previous to the introduction of stake-nets into the Cromarty Firth his fishing in the Conan produced in one year 7656 salmon, while subsequent to their introduction the same fishing produced during another year only 633. But during that latter year Mr James Taylor had intercepted in his stake-net no less than 6500.

It was stated to the Committee by Mr Alexander Fraser, that the rent of the fisheries in the river Ness was, sixteen years ago (prior to 1828), L.1055, and had then fallen to L.124. We believe that its commercial value is now even less than the latter sum, although the revenue which is derived from angling may have increased there, as in most other rivers.

In relation to the supposed decline of our salmon-fisheries, we may state that the late Sir Humphrey Davy delivered into the hands of the select committee of the House of Commons (which sat some years prior to the passing of the Scotch act of 1828) a paper containing the following observations and recommendations. "There is a general complaint," he observes, "of the diminution of salmon in fisheries. In the Thames it can scarcely be said to exist; and even in the Avon, the Severn, and the Trent, it is becoming comparatively a scarce fish. The great northern fisheries, and the Irish fisheries, are much less productive than formerly." He then states the remedies for this national evil to be as follows: 1. To suffer more fish to spawn, and fish of all ages and sizes; 2. to prevent any fish from being killed in rivers after spawning; and, 3. to prevent the young or fry from being destroyed. He is, moreover, of opinion that as all salmon and salmon-trout return to their native rivers, so stake-net fishings ought to be abolished, as they enable persons having no interest in the river to cut off almost entirely its supply of fish, as salmon do not go far out into the sea, and always return along the coast, scenting out, as it were, their own river; and that a strong net put across an estuary might destroy in one year the whole fishery of a river. He recommends that no close wears should be allowed, but that there should be always a free passage for fish, so that early fish may go up as well as late fish; that no machinery should be permitted in a river by which the spawning fish may be killed; that nets should be limited to a certain size, so as to render it impossible to sweep a river; and that no angling should be allowed for salmon till May, nor after October.

Proposed remedies.

The remedies named above are more obvious than easy, and have been not seldom proposed both before and since. They undoubtedly go to the root of the matter, but their enforcement is the difficulty. It has been often tried, but seldom effected. The suggestion as to stake-nets, considering the nature of now vested rights, could never be carried into effect, and, so far as the public interest in a supply of good salmon is concerned, ought not to be so. Besides there are no fixed nets in estuaries, as they are illegal wherever the estuary character is demonstrable. At all events, there is no such thing any where allowed as a net *across* an estuary, or even *linum fluminis*. A free passage must be left, and the so-called estuaries have had ample justice done them,—1st, as in the Tay case, where the sea is declared to end when we reach the "Drumly Sands;" and, 2d, in that of the Dornoch Firth, where the estuary is made to extend to the wild moaning of the "Gizzen Briggs," opposite to, and below the town of Tain. Close weirs on rivers do little harm (such are the productive powers of fish) if properly constructed, and the legal "slap" of 24 hours every week is observed. If a free passage were so left open as to accommodate the fish in the favourite portion of their run up the river, they would all escape, and the weir-dyke would not defray the expense of its erection. Like sheep leaping in single files "each after each" over a broken fence, so would the salmon vault through that watery way. If, again, the main rush of the river were deceptive, and contained a cruive with *hecks*, and the actually open space were in some out-of-the-way quiet corner, the eager and impetuous fish would never make the discovery, nor find out their mistake till it was too late to mend it. If any of these early summer fish got through, their after capture would no doubt please one or more of the upper proprietors, but they would be of little use, parentally considered, because they must bide their natural time to the close, and when that time comes there will be many far fitter for parental functions than themselves, even should they escape the angler's lure. To limit the dimensions of the net would be of little use in rivers the two sides of which, as so often happens, belonged to different persons, and who, if they did not agree to the usual practice of taking alternate sweeps of the whole, would each incessantly harry his own half. To allow no angling till May would deprive the rod-fisher in the earlier rivers of his best months, when the fish are fresh and the waters full. To debar angling after October, or, in other words, to permit it to the close of that month, would be merely an extension of the present period (except as concerns the Tweed, which has seven days more), although, from the mode of expres-

Mackenzie of Ardross, who cherished peculiar views of many other things besides salmon, writes as follows:—"Salmon are always better for being a few days in their native water. It increases, like crimping, the firmness of the fish; insomuch that while a salmon caught in the morning in the sea is soft enough to be boiled and pickled the same evening, one caught in the fresh water retains its firmness, and would break in the kettle if boiled before next morning. The fish curers or boilers, who are great epicures, always accordingly prefer for their own palates fish that have been some days in fresh water."—*View of the Salmon Fishery of Scotland*, Note to p. 42. In regard to the practice of parboiling salmon immediately after they are captured, in order to preserve the curdy texture, it is a good plan if a couple of days has to elapse before they are eaten. But a friend of good taste in Berwick (who dines on the produce only of the *afternoon* tide), tells us, that if a person *must* partake of a salmon killed in the *morning* of the day it is eaten, it is better to keep it cool till dinner time, and then boil it once for all.

Proposed remedies.

sion used, we know not that extension was the object in view. As leading to stricter preservation in the uplands, we doubt not it would be of use.

In regard to the interest of the upland proprietors, which we have always advocated, and have already referred to, we should like to guard against extreme views. They chance to possess a good supply of fine clear shallow water of a rippling lively character, with abundant beds of clean-washed gravel, such as a fond parental salmon loves to haunt. In these, without much trouble to the proprietor, the parr are hatched, and there they dwell during the days of their innocent childhood, and till such time as they migrate seawards. They measure even at the last only a very few inches in length, and do not weigh more than half as many ounces. In obedience to a mysterious and most irresistible, but wisely ordered, instinct, they suddenly descend to certain marine pastures, where their increase of growth is rapid and remarkable. But they are by this time, it may be, a couple of hundred miles from the margin of those tiny streams where they had passed their childhood. They are now well-grown grilse, or even (supposing their second journey to the sea) large-sized salmon. They have descended by a difficult and devious route, along many intervening lands, into the open sea, have wandered at their own sweet will far into that blue profound; and coasting again shorewards in pursuit of food or frolic, to whom do they belong? Certain shore proprietors, to whom the royal right has been deputed by our gracious Queen, or her august predecessors, erect at great expense, and work with difficulty and sometimes danger, bag-nets, or other ingeniously-constructed modes of capture; and when they thus secure a splendid salmon of 30 pounds weight which calls no man master, can any reasonable being maintain that it belongs to some small proprietor, one of the "children of the mist," who owns the barren banks of a feeble tributary among the distant hills, where it no doubt first saw the dim light of day, but from which it had departed of its own accord, so soon as it felt proudly conscious of having become a smolt? There is surely no unjustifiable interference here. The *parr* may have originally belonged to another person (though not necessarily to the proprietor of its native land, who in all probability had no salmon rights whatever), but it has undergone a remarkable metamorphosis, and passed, it may be said, into another state of existence; and, as a *salmon*, it now belongs to whoever possesses and puts in action the legal right to catch it, whether in salt or fresh water. But undeniably there is a natural and necessary connection, as in the relation of cause and effect, between the breeding places above and a productive fishery below; for while we know that without the sea there would be no salmon, so we also know that without the streams there would be no parr—therefore no salmon. But the sea, as usual, is the mightier and more influential power, and eventually yields upon the river produce an increase of many hundred fold. Thus, all that any upland heritor could reasonably claim as his particular share in any salmon would be a small cut about the length of, but otherwise no larger, than his middle finger. At the same time he is entitled to many of these, as his progeny, though minute, are multitudinous; and the unkindest cut of all is that which debars his almost ever seeing a single fin of them again till they are as black as ink, or as rusty as old iron,—for these are the conditions in which the grown fish revisit the shallow streams of their nativity. But the case is too often argued, as if a parr bore the same relationship, even in its extrinsic conditions, to a salmon, as a lamb does to a sheep,—as if the first owner not only bred, but fed and brought it up, and so was entitled to it in its final and complete condition. It is obvious that it is not so. But as the river heritors alone have the direct power of improvement, by breeding and preservation, in their own exclusive hands, it would be good policy to induce them (by making it worth while) for their own sakes as well as those of others, to exercise that power. There is no doubt that the royal grants of river fisheries were given long before those of the coasts were thought of. They proceeded on the observed and ascertained habits of the fish—their periodically entering into narrow waters, and were express in relation to rivers, estuaries, and other inlets; and mainly for this reason, that salmon-fishing, unlike many other kinds, cannot be accomplished independent of the uses of the land. These fine fish do not take in the sea with hand lines, or long lines, or in any other way requiring an act of volition on their own part. They afterwards, no doubt, exhibit a fantastic fancy for artificial flies; but this, with scarcely an exception, is an appetite acquired or manifested only in fresh or running waters. In earlier times the mechanical portion of the art (with the exception of cruives) was comparatively feeble, if not imperfect; and it is only in modern days, when men have sought out many inventions, that the continuous strength of stake-nets planted upon shoal ground, and the resisting power of bag-nets placed in deeper waters, have been brought to bear up enduringly against the force of winds and waves, and the surging swell of the heaviest tidal currents.

Many regard it as a great loss both to Tweed and Tay, that these noble and productive rivers should be divided into so many distinct fishing stations, all wrought separately, whereby the expenses are much increased. Fixed nets require far fewer men, and catch far more fish. On the other hand, the tear and wear at the fixed stations is greater than for net-and-coble. The comparative advantage of simplification in the mode, and fulness of occupation to the people, forms the problem in political economy before referred to.

"The grand evil in the salmon-fishery," observes Mr Mackenzie of Ardross in 1834, "is the multiplicity of fishings, which begets so many contending interests, and makes each individual pursue a selfish system of destruction incompatible with the improvement on a great scale of the fishery. If anything could justify the violation of private rights for the benefit of the public, the owners of minor fishings should be made to sell their rights for a just equivalent, in order to concentrate the fishery as much as possible. If a whole river belonged to one individual, he might do with it as he liked. In such a river there should be no close time. The owner of it would take care to keep it at all times full of breeding fish. He might make it like a game preserve, in which immense quantities would be reared. He would restrict the fishery entirely to a few stations near its mouth, and fish these constantly while clean fish appeared, supplying the public with new fish as they came on, even at the period the old fish were breeding in the upper parts of the river, without the smallest injury to the fishery; but a single upper heritor, were his fishery not worth L.5 a-year, could put a stop to the whole plan. There are, accordingly, no rivers in the kingdom at present under so complete a system of improvement as those of the Duke of Sutherland in Sutherlandshire, under the able direction of Mr Loch, M.P. But this cannot happen in rivers which belong to different proprietors, and, therefore, a close time seems absolutely necessary for such rivers, that is, such a close time as a majority of the proprietors should consider best suited to each river, it being always understood, as we have already said, that the interest of the owners of the rivers and of the public is necessarily the same, viz., the production of as many fish as possible. On the coasts, if coast fishings are to be allowed, the close time should always commence some weeks earlier, as the fish towards close time do not proceed quickly on, and may take that much time to reach the rivers, so that the fish that would pass the coast fishings during that period would not be killed at the rivers, but would be left for breeding.

Proposed remedies.

"We believe that one of the reasons which influenced Mr Drummond in establishing a general close time for all the rivers was, lest the salmon of one river might be smuggled to market as coming from another. But what did it signify, if the fish were *clean*, from what river they came? And foul fish never can be sent to market as clean fish, for their *appearance* would betray them at once. The deception would be seen at a glance. As well might a man attempt to sell a black horse as being a grey one. In truth, no salesman would now venture to present foul fish at market; and if the fish are salted or kippered, we would defy any man to determine whether they were killed a week before or after close time, or, indeed, to bring *legal* evidence to bear on the subject; since, as we said, salmon are as foul in some rivers in August as they are in other rivers in October. Besides, protection to one river can never be a good reason for injustice to the owners of another; and nothing can be more grossly unjust than to deprive the owners of the rivers Ness and Thurso of a great part of their properties, lest foul fish from the Tay or Tweed should be sent to market as coming from those rivers. If the Tay or Tweed are poached, let the proprietors be at the expense of a greater establishment of river keepers, and not look to the annihilation of other properties to save their own purses."

There is no doubt that the Ness and certain other early rivers are put at a disadvantage by the longer continuance of the close time now than formerly. It was proved in evidence before a select committee of the House of Commons in 1825, that when the mid-winter fishings were open, the amount of salmon killed in the Ness during eight years (from 1811–12 to 1818–19) made a total for the months of

December[1]	2405	May	1127
January	3554	June	170
February	3239	July	253
March	3029	August	2192
April	2147	September	430

It further appears, from the evidence above referred to, that during these years no *grilse* ran up the Ness till after the month of May. The month of

June produced	277	August	4229
July	1358	September	1493

We may here observe, that the fluctuations in the salmon-fisheries seem to result not unfrequently from causes over which we have not only no control, but regarding which we have scarcely any acquired or actual knowledge. Clear dry weather, not unusual during the midsummer months of June and July, never fails to affect disadvantageously all fisheries at any distance upwards from a river's mouth. July and August are the chief months for the upward run of grilse. The longer they abide in the sea the bigger they become, so that a September fish fresh from the salt water is twice the size of a June one. The existence in our rivers towards the end of winter or in early spring of grilse which have spawned, and yet weigh only three or four pounds, is of itself a conclusive proof of the retardation of growth in fresh water. These small fish must have entered the river water soon after midsummer of the preceding season, but had made no progress. Had they remained in the sea till autumn, their dimensions would have been considerably greater; or had they spawned sooner, or descended more speedily to the sea, they might have returned riverwards in spring *as small salmon*, while their less adventurous brethren of the same age were still in the streams as grilse.

The working of net and coble does little or no harm to the fry, and cannot injure the spawning beds, either by displacement or otherwise, because these are always either higher up, or in shallower water, than suits the process. Many of the best breeding places are in the tributaries, and the majority of these have never any salmon in them during summer. The clearness of the water at that time, and its small amount, as effectually debar their ascent as if a cruive dyke were thrown across their mouth. Fish in a large river have been known to wait for six weeks near the still too shallow mouth of a favourite tributary, that they might ascend the latter with a view to spawn, rather than continue their journey up the former, which was not their native home. They ascend in the course of the autumn floods, and descend again when the winter is well advanced, and during early spring. Thus the majority of these upland beds are nothing but nurseries, of little or no value to the proprietors, but of infinite importance to the seaward owners of the salmon-fisheries down below. In the Tay, for example, there is no fishing of any consequence (angling of course excepted) beyond the mouth of the Isla, about eight miles above Perth, although Lord Breadalbane has a few good hawling places in Loch Tay, and fish continue their courses into the wild uplands watered by the Dochart, as far as they can go. We saw, when last in that quarter, a brace of fine salmon, rather gray, but in excellent eating order, and weighing nearly 42 lb. the pair, killed with the fly, a short way below the well-kept hostelrie of Luib. But upon this principle of non-ascent in summer, many upper proprietors of small streams, although entitled to consideration, are in error when they suppose that fine angling would necessarily come their way if there was an earlier close in autumn, or less assiduous fishing down below. There cannot be many well-conditioned fish in the smaller streams, because they do not desire to *run* till the commencement of the autumn floods. If there was no net-and-coble fishing during the first fortnight of September, no doubt some fine fish would make their way well upwards; but even if all obstructions were removed, there would still be no good summer angling for salmon in the higher or smaller streams owing to the deficient supply of water, and its extreme clearness. No modification of the present law would give good angling in the upper countries that would not be too injurious to the commercial fisheries; but a somewhat earlier close would be of advantage to both parties—immediate to the one and eventual to the other.

In favour of an altered close time, that is of an *earlier close*, it ought to be borne in mind that the parent fish which ascend from the sea in autumn are the best and most productive breeders, although themselves of less value as articles of food. Those which ascend later, or in wintry weather, may be also good breeders; but the conditions under which they then exist are less favourable for the deposition and future safety of the spawn.

It has been distinctly ascertained that no salmon grows, or at least increases in weight of flesh (although the bony structure may be enlarged), after it has entered the fresh waters. On the contrary, it rather decreases in weight, as it admittedly deteriorates in condition, and consequently in value, as a marketable commodity. We think it is a fair inference, and believe it to have been confirmed by actual observation, that salmon, whether male or female, entering a river in spring or early summer, and remaining there for months, would, from the deteriorating influence of river water, and the absence of their highly nutritious marine diet, whatever that may be, suffer not only in the fulness of their general condition as to fat and muscle, but also in the development of their sexual attributes. It is indeed an ascertained fact, from repeated observations by various individuals, that many female salmon which have been long in fresh water, have the ovaries not only not increased by the advance of the season, but sometimes diminished almost to extirpation. Thus it is probable that the use of such individuals as breeders is lost for a year at least, if not for ever.

[1] Some of the Irish rivers also yield a good December fishery of clean salmon, or did so before restricted by a change of close time.

Autumnal fish the best breeders.

If, on the other hand, they are still able to propagate their kind after this lengthened sojourn in the "rivers of water," there is a probability that their progeny will be less numerous, and of inferior nature, to such as derive their origin from parents fresher from the sea, and in which the sexual system is capable of more fully performing its functions.

It is satisfactory to consider, in connection with this view of the subject, that the capture of salmon in spring and summer does not in fact interfere with a good and abundant supply of future fish. On the contrary, that it is better that such supply should proceed from the autumnal *run*, and thus two objects are attained,—1st, the markets are furnished for a length of time during spring and summer with fresh-run and finely seasoned fish, the spawning period of which is far distant; and, 2dly, the young brood are produced by parents which have been nourished for a prolonged period in the sea, and although deteriorated as articles of food by the advanced condition of the spawn, that spawn itself is fully developed—the chief consideration in respect to breeding fish.

But although the late-run fish are the best breeders, the sooner that these are encouraged to spawn the better. When the net-and-coble and stake-net fishings are continued working well into September, a large proportion of the finest early-breeding fish are destroyed, and just at the time that their breeding functions might be most successfully performed. About this period the fords or shallows (the chief spawning places) are well filled, although not overfilled, with water. The fish are consequently not tempted to spawn too near the margins, which they are apt to do in floods, and in which case the spawn is likely to be left dry when the waters recede. At this time, too, the rivers are free from ice, which is injurious to the brood, not so much by destroying the spawn, which is of a hardy nature if once properly laid and covered up, as by preventing the process of spawning itself. Or if there is no severe frost during the late or winter spawning, then floods or *spates* occur, and are very hurtful, because, although the parent fish always prefer spawning in lively or rippling water, they cannot of course do so advantageously if the current over the shallows is too strong. This increased current is apt to sweep away what would otherwise be the sinking spawn, or prevent its being properly covered up.

Thus, as either flood or hard frost is disadvantageous to the successful performance of the spawning process, the greater number of fish that are allowed to spawn early the better. For this an additional argument may be assigned. There is every reason to believe that fish which spawn early descend again all the sooner to the sea as kelts, are there invigorated and renewed in strength and condition, and return early to the rivers, so that at least a portion of them will seek to re-ascend as clean fish in spring, when the marketable value of salmon is greatest. A sufficient number of salmon will always remain throughout the summer season in the sea, and ascend towards the spawning beds in autumn; and so great is the productive powers of these fish, that a comparatively small number of breeders, if properly protected, and allowed to spawn successfully during the most fitting period, will suffice to stock the rivers, so that no limitation need be made of the numbers caught during spring and summer.

From the principle here set forth, it will follow that no particular advantage need be expected to follow from preserving the courses of a river from the angler during the earlier or middle portions of the season. For example, we do not see that any great benefit would arise to the Sutherland rivers from the spring and summer jubilee of 1848, because, as no fixed obstructions are offered to the ascent of the fish there after the 25th day of August, a sufficiency of spawning fish would be sure to make their way upwards in good time from the sea, and would prove better spawners than those which had previously ascended the rivers. We would therefore even go the length of saying, that it would be better for the spawning beds not to be subjected to the chance of being occupied except by the autumnal-run fish, and therefore the smaller the number of early (and necessarily deteriorated) salmon which have abode long in the fresh water that are allowed to remain in it during the actual spawning season the better. This is of course an argument in favour of rod-fishing, and the mere fact of its being agreeable and advantageous to the angler is certainly in no way against it, if otherwise true. If all stake-nets were dismantled, all bag and cruive nets removed, and all net-and-coble fishing terminated, by the 20th of August, we have no doubt that a deal of productive spawning would take place in September, and that a corresponding increase of grilse and salmon in our rivers would eventually take place. Rod-fishing might be continued without disadvantage up to the 20th of September. The chief damage to spawning fish is done by the poacher's leister rather than by the angler's rod. The fish, while engaged on the shallows best adapted for spawning will not take the angler's fly, although the leister takes them whether they will or no. There are always, even in autumn, fish less advanced with spawn than others, and which keep for a time in the deeper pools and stronger currents, where the angler chiefly plies his vocation; and the taking out of these fish is much less wantonly injurious than destroying the others, both because they are themselves in better condition, and so of greater use, and because, as winter breeders, they would run the risk of spawning (as already stated) under disadvantageous, possibly unproductive, conditions. Angling being also a favourite recreation, and frequently advantageous to the proprietor as a source of income, it carries its compensation along with it. And another direct advantage, we doubt not, would arise from the fact, that while the authorized and legitimate angler is on the river, the illegal poacher is more likely to keep away from it, and the greater value of the privilege of angling, if continued after all kinds of *netting* have ceased, would induce proprietors and lessees to be more active and zealous in their general guardianship of the streams. As a matter of political expedience also, it may be advisable to allow an extension of time in the angler's favour, as not unlikely to propitiate some legislators, who might otherwise object to any change at all.

We doubt whether a bill proceeding, as was at one time proposed, upon a presumed knowledge of the varying habits of salmon as entering certain rivers sooner or later than others, and so dividing the country into different districts, could be either made practical in its application, or worked with good effect. A lengthened inquiry and investigation of the actual facts, and a detailed and authenticated report upon their ascertainment, would be indispensable; and it might be difficult to reconcile competing interests, or draw distinctions between rivers physically the same though in different districts, or physically different though in the same district. A river flowing out of a valley filled with water (that is a lake) may fall into the sea in the near neighbourhood of another river which in early spring draws its main sources from numerous alpine streams subjected to the icy influence of frost. The lake-born river will be an early one, that of the open valley and hilly district a late one, or at least later than the other, although both co-exist in the same district; so that almost every river might require to be defined and designated in the act, and an appropriate clause inserted in relation to each. This complication would be found inconvenient if not impracticable. At all events a commission of inquiry would be necessary to furnish the groundwork of any admissible enactment proceeding upon the principle of local divisions, or districts. A general act may doubtless entail some little

Close-times. hardship by debarring the natural advantages of a few peculiar rivers, but on the whole the general interests will be best guarded by an act of general application. A restricted act, applicable to a single river, might, in many cases, be difficult to decide upon, even by the proprietors themselves, in so far as the interests of the upper and lower heritors are not only different, but stand directly opposed, or at least are deemed to do so. A proprietor of a stake-net in the sea, or of a net-and-coble fishery in an estuary, might possibly deem himself aggrieved by such an early close as would benefit him whose restricted stream winds its far upland course among the desolate hills, and whose only chance of a well-conditioned fish must almost entirely depend on, or at least be greatly increased by, an early termination of the commercial fishery down below. In the long run, we believe, the advantage would be mutual in the more careful protection of the breeding fish, which would soon ensue, and the consequent increase of the general stock.

The upper proprietors would thankfully accept of what, under the circumstances, they are entitled to—a week or two of rod-fishing—as some compensation for what they have lost in modern times by the increased and more skilful application of the various devices now fallen upon by the lower and seaward proprietors to ensnare the finny tribes. These upper heritors have but a slight chance of ever catching a good fish in their own waters, although the responsibility, and a portion of the expense, of protection during the breeding season, are not seldom thrown upon them. They are thus, as Sir Walter Scott used to express it, reduced to the condition of mere "clockin' hens" for the hatching of other people's eggs.[1] As to actual injury committed by the angler, it ought ever to be borne in mind that the rod is but a precarious engine of death, at no time very deadly. From the frequency of floods in the end of autumn, not a great many days during the last three weeks of the season would with certainty afford successful angling; and a strong salmon not seldom takes his own way both with hook and line, although he must succumb to the nocturnal glare of the burning brand and the leisterer's deadly spear.

The art of angling has been for a length of time among the most highly favoured and most assiduously pursued of all our British sports, and has consequently become of great value to proprietors in a pecuniary point of view; so whatever is likely to add to that value becomes of great importance. Many considerate people are of opinion that some modification of the laws relating to salmon would be advantageous, but the subject is jealously regarded by others, and several attempts to obtain a modification of the existing act of parliament (9th Geo. IV., cap. 39) have failed. In rivers which pertain entirely to a single person, or in others where the various proprietors have agreed to act in unison, the use of nets and cruives is voluntarily given up some time before the legally required period, and advantage has been found to result therefrom. It has hence been inferred, that if this wise practice were enforced in all rivers, still greater benefit would arise. What is called the close time, during which it is illegal to kill salmon, or fish of the salmon kind, extends at present, as regards all rivers north of the Tweed, from "between the 14th day of September and the 1st day of February"—that is, as we construe it, no one is permitted to angle for or otherwise kill salmon from the 15th day of September to the 31st day of January, both included. Certain southern rivers of Scotland are regulated by special acts of their own, with a reservation for an additional time in favour of angling. The Tweed, for example, closes as concerns nets or commercial fishery on the 15th day of October, but continues open for rod fishing till the 7th of November. It opens both for net and rod fishing on the 15th of February. The Annan, in accordance with its own special act (4th Vict. cap. 18, May 1841) is closed "*between* the 25th day of September and the 10th day of March" as against net-fishing; the legal period being prolonged in favour of rod-fishing until the 1st day of November inclusive, while the day of opening is the same for both modes. The Nith opens on the 10th of March for rod and net fishing, and closes for both on 25th September.

Nothing is more frequently observable, or better known, than the fact that there is a remarkable difference in the habits of salmon of different rivers as regards their period of entering these rivers.[2] Whatever their ultimate object may be, it is clear that the spawning process, which does not usually take place till towards the commencement of winter, cannot be much in the minds of such fish as seek the fresh waters in early spring. It is a mistake, however, to suppose that there is a corresponding difference in the actual periods of spawning. Some rivers have a greater proportion of well-conditioned fish for a later period than others, but to delay or greatly alter the close time on their account would be very injudicious, notwithstanding the admitted hardship upon the proprietors of certain places where fresh-run fish are found in good order even for some weeks after the present close. A select committee of the House of Commons, appointed to inquire into the expediency of regulation by a varied rule, reported (in 1836) as follows:—"The only object of the close season being to afford protection to the fish when they are breeding, and during their state of exhaustion consequent upon it, your committee are of opinion that the legal close time ought to be so regulated as to coincide as nearly as possible with the period so defined by nature. It has been established in evidence, that in different rivers *the periods at which the salmon ascend the rivers for the purpose of spawning*, and afterwards descend towards the sea, vary considerably, and therefore, upon the principle above laid down, your committee are of opinion that it would be advantageous to the general interests of the salmon-fisheries of Scotland to have the fence-months or close time so regulated according to the respective rivers or districts, instead of having one uniform season as at present." It was upon this principle that the bill introduced by the late Mr Patrick Stewart and Mr James Loch was framed, not, we fear, without some confusion of the running and the spawning periods, which have often little to do with each other. It divided Scotland into twelve districts, the majority of which were made to differ from each other in their times—the Ness, for example, being made to close from the 16th day of July to the 1st day of December, and so on with the others, only three of them remaining as they are now. Fourteen clear days were to be allowed in each district after the close for the

[1] The illustrious sheriff of Selkirk had a kindly bias towards the sports of the people, of which the spearing of salmon is one of the most ancient and exciting. He no doubt often saw, amid his own nocturnal musing, the flickering lights along that turfy shore, starring the far reaches of the river, while he listened to the leisterers' cry, with no "act anent the killin of black fish" in all his thoughts. He has even thrown himself (dramatically) with great gusto into the feelings of those who have sometimes taken the law into their own hands by the destruction of "fixed engines" at a river's mouth. "In truth I heard it, provost; and was glad to hear that the scoundrels had so much pluck as to right themselves against a fashion which would make the upper heritors a sort of clockin' hens to hatch the fish that the folks below were to catch and eat."—*Redgauntlet*.

[2] The subject of the close time is still further complicated by the fact that several rivers yield both early and late fish, because certain of their branches or tributary streams produce some the one and some the other, all having previously to ascend by the same channel from the sea.

District system.

purposes of angling. This bill was either abandoned or thrown out, and a similar fate has attended several others. A previous one had been introduced by the same parties (in 1835), which proceeded on the principle that the proprietors of salmon-fishings in rivers, at a meeting to be called as therein provided, should determine, by a majority of their number and value, the period of close time in each river, &c.; that there should be no fishing for salmon after 1st September, but that twenty-one days should be allowed for the exclusive use of the rod after the commencement of the close time. In 1839 two bills were brought in by Mr Wallace and Mr Hume—one proposing that the fishing season should commence generally over all Scotland upon the 10th of January, and terminate upon the 24th of August—the other legalising twenty-one exceptional days in favour of angling with the rod. Passing over one or more intermediate attempts at legislation, we may briefly notice the bill prepared and introduced by Mr Edward Ellice and Mr Thomas Mackenzie in the spring of 1842. With a view to reconcile or accommodate the interests of all parties, it threw the arrangement and decision of the whole affair into the hands of the commissioners of the Board of Fisheries, thus assimilating the Scotch to the Irish system. It was likewise laid upon the shelf. The latest attempts at salmon legislation was the bill introduced by the Duke of Argyll, and which passed through the House of Lords in 1851. It made the close time commence somewhat earlier than it does now, was more stringent in its enactment in relation to the "Saturday's slap" of stake-nets, &c., and gave the angler a chance of some amusement for a week or two in the upper country by prolonging the period of the rod. It was rejected by the House of Commons. So the regulating act for Scotland is still the 9th of George IV., commonly called Home Drummond's Act, passed in July 1828.[1]

One of the boldest proposals for the simplification of the salmon-fisheries of rivers has been given in recent years.[2] The writer holds that the entire system, whether by fixed or moving nets, proceeds on a false plan, bequeathed from times under different conditions, which performs badly and expensively what might be well accomplished at a small cost. His plan of radical reform is this,—to erect and work in each river, at such place or places as might be found most suitable, some engine which shall, with easy and well regulated alternations, capture every ascending fish, or allow all, or a sufficing number, to pass up at proper times, dividing the produce among the proprietors of the present fisheries, in such proportions as shall be equitably ascertained by evidence and arbitration. We fear, from what we know of human, as well as of salmon, nature, that this scheme is Utopian, and will never come to pass. Another and a prior proposal was made by Mr John Younger of St Boswells, an ingenious writer of the hard-working and self-taught school.[3] Having full knowledge, and a high estimate, of the great angling value of the Tweed, he is of opinion that no other engine but *the rod* should be allowed at all, and that its use should be legalized by act of parliament all the year round. There is no doubt that our rural and village population, having an impression, however erroneous it may be, that their natural rights are somewhat unfairly abridged by the privileged claims of the higher orders, consider close time as the poor man's proper, because now only, period. Being also a time of delegation to the water-bailiffs, these watchmen of the night are more easily evaded, or effrayed, than would be the local lairds or tenants, had the latter any great inducement to interfere. Of all the fresh-water piracies, the practice of leistering is the most deadly and destructive, as well as daring, and is habitually effected in spite of whatever police force may be arrayed against it. As the use of the leister is, for the most part, a nocturnal practice, and lights (in themselves illegal) are necessary both to detect the fish and to astound them, the poachers can scarcely hope to conceal their nefarious proceedings, and so assemble in full force. With "visage discomposed," that is, with blackened faces, and otherwise arrayed in wild attire, they descend upon a spawning place, where, it may be, fifty pair of large and heavy fish are gathered together, and with blazing lights and long-shanked leisters they com-

[1] Although exceptional cases may occur in several rivers, it is certain that the great mass of salmon are in bad condition by the month of October, and frequently long before it. They continue, with the same exceptions, in that unsound state for many months thereafter. The present act of parliament is an "Act of Uniformity" for all rivers north of the Tweed, and although it may bear hard upon the Ness and other early streams, it would be difficult to enact local regulations, giving a difference of times to different districts. As the subject, however, is not unlikely to have legislative attention again directed towards it, we think advantage may arise from our here re-printing the boundaries and their respective seasons, as given in the bill constructed on the local principle, and presented to the House of Commons:—

First District. From Duncansbayhead in Caithness, to Tarbetness in the county of Ross, comprising all the rivers, streams, lakes, waters, estuaries, and sea-coast, situate between these two points, from the *twentieth* day of *August* to the *fourteenth* day of *January*, both days inclusive. *Second District.* From Tarbetness aforesaid, to Fort George Point in the county of Nairn, including the Beauly Frith and the rivers connected therewith, except the river Ness, from the *twentieth* day of *August* to the *fifth* day of *January*, both days inclusive; and for the said river Ness, from the *sixteenth* day of *July* to the *first* day of *December*, both days inclusive. *Third District.* From Fort George Point aforesaid, to the Knockhead of Cullen, in the county of Banff, from the *first* day of *September* to the *seventeenth* day of *January*, both days inclusive. *Fourth District.* From the Knockhead of Cullen aforesaid, to Trouphead in the county of Banff, from the *fourteenth* day of *September* to the *thirty-first* day of *January*, both days inclusive. *Fifth District.* From Trouphead aforesaid, to Dunottar Castle in the county of Kincardine, from the *first* day of *September* to the *seventeenth* day of *January*, both days inclusive. *Sixth District.* From Dunottar Castle aforesaid, to the Redhead in the county of Forfar, from the *fourteenth* day of *September* to the *last* day of *January*, both days inclusive. *Seventh District.* From the Redhead aforesaid to Fife Ness, from the *twenty-seventh* day of *August* to the *twelfth* day of *January*, both days inclusive. *Eighth District.* From Fife Ness aforesaid, to Berwick Bounds, from the *twenty-seventh* day of *August* to the *twelfth* day of *January*, both days inclusive. *Ninth District.* From the confines of the Solway Frith to the northern boundary of the county of Ayr, from the *fourteenth* day of *September* to the *thirty-first* day of *January*, both days inclusive. *Tenth District.* From the northern boundary of the county of Ayr, to Ardnamurchan Point in the county of Argyle, including all Western and other islands situated within the parallels of the said two points, from the *fourteenth* day of *September* to the *thirty-first* day of *January*, both days inclusive. *Eleventh District.* From Ardnamurchan Head aforesaid, to the Point of the Coygach in the county of Ross, with all the Western Islands situated within the parallels of these two points, from the *first* day of *September* to the *seventeenth* day of *January*, both days inclusive. *Twelfth District.* From the Point of Coygach aforesaid, to Duncansbayhead first hereinbefore mentioned, from the *twentieth* day of *July* to the *sixth* day of *December*, both days inclusive; and for "the Lewis," from the *first* day of *August* to the *seventeenth* day of *December*, both days inclusive; and for "Harris," from the *tenth* day of *September* to *twenty-sixth* day of *January*, both days inclusive.

When about to apply to Mr Loch for some information regarding the natural data on which the preceding divisions were established, we heard with deep regret of the death of that estimable person.

[2] *Edinburgh Review*, vol. xciii., p. 367.

[3] Mr Younger is by trade a shoemaker, and dresser of artificial flies, in the village of St Boswells. He has written an excellent little book *On River Angling for Trout and Salmon* (Edin. 1840), and is also the author of an essay *On the observance of the Sabbath*, which gained for him an English prize, and led to his showing himself on the platform of Exeter Hall, from which we doubt not he gladly returned to the gentler murmurs of the Tweed.

Mr Younger's proposal.

mence, and speedily complete, their remorseless slaughter. Meanwhile a dozen paid bailiffs may be innocuously shivering on some neighbouring height, but no more able to interfere with what is going on than Tam O'Shanter in the midst of the witches' joyous dances would have dared to seize upon the black piper. This practice is still a prevailing one in the higher portions of the Tweed, and is prosecuted with the greater facility and success, in consequence of the tenants, or resident proprietors, if such there be, finding it more difficult to sally forth at dead of night to prevent such improvident destruction, than to tarry at home and divide the spoil. Such a dialogue as the following may be not unfrequently heard between a farmer's servant and his employer during close time. "Maister, twa or three o' us are thinking o' lighting a bit bleeze at the *reds* (spawning beds) the nicht, up at the shaw-brae fords, whar we saw them tumlin up this afternoon, like brewers' swine drunk we maut-draff." "Weel, Davie, I daresay, for my pairt at least, ye may just tak what ye can get when ye hae them here, as I'm sure I havena seen three good fish in our water thro' a' the simmer. They kep them a' about Berwick or Norham now, wi' their lang nets, except just a while at the tail o' the saison, when the floodings get ower heavy for their net warks."[1]

Before the passing of the present act of parliament the Tweed opened on the 10th of January, which was much too early for so late a river, and interfered with the breeding fish. As it now stands, the time (15th February) is fully too soon, as it gives occasion to the catching of so many newly-spawned, or otherwise ill-conditioned fish.[2] It also involves this further inconsistency, that leistering, and all other unkindly and injurious practices, which are illegal on the evening of the 14th of February, become legal on the morning of the ensuing day, when they cannot be put in practice without an equally unnecessary waste of life, in the destruction of fish almost utterly useless for all domestic purposes.

Now Mr Younger's proposal is, that as the proprietors consider the produce of the running waters of as much importance as the productions of the solid land, they might make the former much more valuable as concerns both profit and pleasure, by abolishing all net and leister fishing at whatever time, and instead of expending their money in maintaining a strong, though seldom effective force of bailiffs, they should raise funds to lease all the now commercial fisheries at the river mouth, or upwards, so as to admit of a free and continuous accession of fresh-run fish all the year round. "If the net-fishings are worth being rented by individual tacksmen, they are surely worth more in value (overlooking the sport) to the whole proprietors of seventy miles of the Tweed. Those rents would be, individually, a mere fractional consideration to the rents that might be drawn in letting mile-lengths to gentlemen rod-and-line anglers, who cannot, under present arrangements, be one-hundredth part accommodated. The benefit, too, to the localities where the anglers would be thus attracted by their favourite amusement, would be worthy of consideration. The distribution of salmon in the river generally would depend solely upon casual floods throughout the year. There would always be plenty of fish for the rod; many would live to attain to a great size, and rod-fishing would then be one of the most pre-eminent, desirable, healthful, and exhilarating standard amusements in our country. It would beat Grecian games, as well as English horse-racing and hound-coursing, all to nothing. The bodily exercise then would place the angler on the top of the calculation of the bill of health. The excitement would be one of the most nourishing principles of the mind, without the engrossment of the faculties from higher pursuits. It would be a charming relaxation from sedentary employments and severe studies, besides an honest source of livelihood for a few poor fellows like myself, who, living by the side of the waters, have from observation and practice, acquired a taste and use of hand in practical fly-dressing, and the preparation of other necessary tackle, rods, and lines, to dispose of to our richer amateurs of high fancy for the gentle craft."[3] We believe that the angling rent of a river, with such a lengthened and continuous, yet finely varied flow, as that of Tweed, might really be made to equal, if not exceed, the present commercial result, which we have shown has not much exceeded L.5000 per annum for many years, and is now far below it. But the plan might be modified so as to admit of an occasional, yet advantageous, working of one or two seaward stations for the markets, with ever and anon, especially in showery weather, a prolonged period of free ingress to a few thousand "bits of silver," with permission to make their way upwards and along that lengthened course, to be assayed in fair proportions, here and there. An objection, however, to the practical fulfilment of such a plan, must not be overlooked, in the exclusive right which some of the older proprietors possess, not only to their own salmon but those of their neighbours. Many *portions* of old estates have been sold to new families, the original proprietor reserving the right of salmon-fishing to himself and his successors. We believe, for example, that he who, in one sense, was the greatest man upon the Tweed, Sir Walter Scott, had no legal power to take a single salmon from the Abbotsford portion of the river, the "Royal Fish" being, by reserved right of ancient grant, the property of an old border family, the Scotts of Gala, who had in earlier times dispossessed themselves of the land eventually acquired by the great Magician. We believe the scheme could never be reduced to practice.[4]

Although all salmon deteriorate rapidly in fresh water, and are always the better-flavoured the nearer to the sea, or the shorter their time out of it, yet the sea-borne fish also decline greatly in condition by the close of the season. However, good individuals do continue to show themselves from time to time, which have not yet lost "all their original brightness," and these, of course, would bring a high price, supposing their capture and sale were legalized. The largest, and some of the finest of the late or winter running fish, are those called locally on Tweedside the "grey school." The lateness of their arrival indicates that they are also among the last to spawn. Though always late, they are by no means pointed as to the precise period of their advent, being guided, if not constrained, by the conditions of the river. They seldom show themselves till towards the close of November, and become more frequent in the course of the two ensuing months. Their arrival in close time, according to Mr Younger, in a great measure accounts for their large size, "escaping in their youth the nettings within tideway, unlike most of our other summer fish, and thus live to increase with age. Hence, if not our finest fish, they are at least our heaviest and most valuable, weighing from 12 to 25 lb. Hence, too, when they get early up the river, they are

[1] Blackwood's *Journal of Agriculture*, new series, No. 15, p. 505.

[2] It might be supposed that the bad condition of these fish would prove their safe-guard, and that although their capture may be often unavoidable, they would be immediately returned into the river. This was formerly and in some stations may be still the case; but in many instances they are sent off with their false fresh-water shine upon them to Leeds and other large inland towns, where there are many thousands of worthy people who have no knowledge of fish.

[3] Blackwood's *Journal of Agriculture*, No. 15, p. 506.

[4] The Duke of Roxburghe, and other great proprietors, would be enormously benefited by the removal of the commercial fisheries, but who could force them to share their increase with others, or to join with the general company of anglers, when they have already as much as they need, and are not asking for more?

The "grey school."

grand sport for the rod-angler, strong and fresh, like a grass-fed heifer a little gone in calf. It has a spirit-stirring effect to feel their tug, and see their first grand sally and plunge abroad in the river, at the end of a tight gut line." We do not agree with our author in supposing that these fish of the "grey school" constitute any special kind of themselves, or that there is anything in the habits of their early life that renders them less liable to fall victims to the ruthless net than their neighbours. They have not escaped in consequence of belonging to a particular school, but the converse is the case; and had they been sooner killed, they could not have been detected as belonging to any school at all. They have *chanced* to escape the net and other accidents by flood and field; but the chief cause both of their diminished lustre and increased bulk, is simply their having remained for a month or two longer in the salubrious sea than the rest of their relations. We have already said, that it is only among its marine pastures that any salmon grows. In a river it never increases at all except in ugliness.

Although the Tweed does not now open till the 15th of February (a fortnight later than all the more northern rivers), many think the time is still too soon. It is well known that on that day a great slaughter sometimes takes place at several of the netting stations, not only of kelts (or spawned fish), but of what are called *kippers* and *baggits*, that is, male and female unspawned salmon. Mr Stoddart states, that scores of ripe spawners have been captured below Tweed Mill during the opening week of the season, and that he has known of eighty she-fish, all large and primed with ova, having been taken in a single day from the Tweed near Twizel. In connection with this wanton waste of life, he makes the following very judicious proposal:—that the proprietors, or others holding salmon-fishings on that fine river, shall instruct competent persons to attend at the netting stations when the season opens, for the purpose of expressing and mingling the ova and melt of the unspawned fish, and immediately committing it to "redds" in the river, formed, in imitation of the natural places, by plow or spade. He opines, that for every clean or fresh-run fish taken in the Tweed for the first fortnight, there are at least a dozen of kelts, and four or five unspawned fish in a very forward or mature state. These are unavoidably captured by the same sweep of the net that secures the marketable fish, and therefore no extra expenditure would be required to obtain a great supply of spawn. There is here a vast amount of incipient life to be rescued from destruction, and which, if placed in properly prepared receptive beds of gravel, would eventually produce a great increase. Two hundred baggits, each yielding say 10,000 ova, would produce, supposing all were hatched, *two million* of fry, all vitalized at the expense of a few pounds sterling. Even supposing many of the eggs to be unproductive, and the greatest and most reckless destruction also to ensue of the future fry, still an addition might surely be relied upon of many thousands.

Mr Stoddart assumes the number of female fish which spawn annually in the Tweed to be 15,000, and he takes 10 lb. as their average in respect to weight. A ten-pounder is believed to carry 10,000 ova, and that number multiplied by the amount of fish, gives 150,000,000,—a very fair supply, as it seems to us, for the general market, if they all came to hand.[1]

Bull-trout of the Tweed.

The great abundance (as shown in our Tweed table) of that large species of sea-trout (*Salmo eriox*), called bull-trout, or Berwick trout, in the lower portions of the Tweed, is too remarkable to be passed without remark. The number taken on an average of many years back has been about equal to that of grilse, and about four times that of salmon. This applies to the river, while on the outward or coast fisheries it is quite different, the proportion of trout in these latter reaching to not more than a ninth of that of grilse, and a fourth of that of salmon. Thus by net-and-coble are taken three or four trouts for every salmon, while the fixed engines secure three or four salmon and nine or ten grilse for every trout. This curious disparity is explained by the local fishermen as follows. When a salmon or his aspiring progeny, a grilse, strikes the *leader* or shoreward portion of the fixed net, he follows close along its side till he voluntarily, though in ignorance, enters the inclosed chamber or trap, into which it conducts; whereas the bull-trout, whether naturally more acute and observant, or, for his size, of greater age, and, consequently, experience in the world, when he comes upon the leader, falls away backwards from, instead of submitting to, such treacherous guidance. He has thus an increased chance of eventually making his escape, at least from these marine dangers, by taking more outward bearings for his next approach. A glance at our table of the produce of the Tweed will suffice to show, that during the first quinquennial period, the average proportion of trout to salmon was as three to four, while during the later of those periods it was as four to one. This enormous change of proportion between the kinds of fish which the fixed nets spare and those they capture, has been noted as of "terrible significancy."[2] It has been found, that on an average of seven years the proportions of the three kinds above referred to, taken respectively by the shore and river fisheries of the Tweed district, is as follows:—For every 100 salmon, the shore takes 313 grilse and 34 trouts; the river 438 grilse and 333 trouts. For every 100 grilse the

[1] The quantities of spawn said to be contained in various fishes are probably in many cases assumed rather than ascertained. The general statement in regard to the species with which we are now engaged is, that a grilse, or a small salmon, contains about 5000 ova, and that a fish of 20 lb. contains as many as 20,000 ova. We have not ourselves acquired any precise knowledge of this matter from actual observation. The following statement, however, may be relied upon, as coming from the pen of an excellent sportsman and persevering inquirer, the late Robert Wallace, Esq. of Kelly:—"I went yesterday, 11th September 1848, to fish in the river Carron, which falls into the Dornoch Firth, where the counties of Ross and Sutherland meet, at Bonar Bridge. The banks showed evidently, by the footmarks along them, that the river had been closely fished before my arrival, and left but little prospect of much sport; and it so happened that I had not a rise till past four o'clock, after which I raised four fish in very shallow water, slightly hooking two, and killing one of the others, a small female grilse of only five pounds weight, nearly one pound of which was roe, already grown about the size of No. 2 shot; and this, be it remembered, in a small grilse, which many self-sufficient and very learned sportsmen insist are not breeders, although all really practical men, whether fishers or dealers in salmon, know quite well that grilse are even more early breeders than full-grown salmon. Well, the roe in my five-pound grilse counted no fewer than 3782 grains, and to the extent of that number I have marred the chance of a similar quantity of smolts going to sea, and returning free of cost of any kind, as a most delicious fish to eat, and a capital size to angle. The mischief I happened to do on the Carron has been done in a greater or less degree by every successful angler over all Scotland, including of course those on the Ness, and especially the fortunate captor of its annual boast, 'the big fish.' The law sanctions the destruction now universally complained of, so that those who act under it must not be found fault with; but the *law itself*, and those who doggedly maintain it, must bear the blame; thus raising the question, Should such a law remain any longer unrepealed?"

The following further statement on this curious subject is from Mr Foley of Lismore in Ireland. The left lobe of the roe of every salmon is larger than the right; and in his opinion the right and left lobes contain distinct genders of fish. On the 17th of September 1824, he took a 15-lb. female salmon, the roe of which contained 10,260 eggs. On the 16th of October he took a 10½-lb. fish, the right lobe of which contained 4612 eggs, and the left weighing 14 ounces, 4816 eggs.

[2] *Edinburgh Review*, vol. xciii., p. 356.

Bull-trout of the Tweed.

shore takes 32 salmon and 12 trouts, the river 23 salmon and 76 trouts.[1]

It is alleged that these sea-trout, or bull-trout, of the Tweed, prey upon the ova and fry of the true salmon; and it certainly appears from the above as if the Tweed salmon were diminishing, while sea-trout were on the increase. At the same time it is not easy to understand how the supply of grilse is not diminished in the same proportion by the destruction of the young. As sea-trout are not alleged to prey on grown grilse, it might naturally be supposed that a river well frequented by the latter would also in each successive season produce a corresponding amount of salmon; but it may be, that by means of a more skilful and assiduous mode of fishing a greater proportion of existing grilse are captured than in former years, and so the supply of salmon is diminished by two causes combined, viz., the destruction of ova and fry by the bull-trout, and an increased proportional capture of a diminished number of grilse,—that proportion still yielding the same supply to the market as before, but necessarily debarring the after occurrence of the old amount of salmon, which are the fish of the ensuing year. Whoever kills a grilse one season, destroys a salmon in expectancy for that which follows.

The destruction of salmon spawn by trout is strongly illustrated by the following extract of a letter from Mr W. H. Haliday. It relates to the capture of salmon in Galway, preparatory to the stocking of a small rill at Outerard with impregnated ova:—"A very curious fact was also ascertained in the course of this experiment. In taking up the spawning salmon we also caught a quantity of trout, and *in every instance we examined, save one,* these trout contained salmon ova, on which they were preying. From the gullet of one large trout we considered that 600 were by pressure ejected; and I retained this, along with a further quantity from other trout, deposited it in boxes isolated from the others, and found that a considerable portion of it came to life." Mr Buist confirms this destruction of ova by informing us of the fact, that the men employed upon the Tay in taking up the breeding fish secured a whitling or sea-trout, of not more than three-quarters of a pound in weight, and observed salmon ova coming out of its mouth. This fish being brought to Perth for examination, 300 impregnated salmon ova were taken from its stomach in an undigested state. "It may therefore fairly be presumed that this youngster had taken this quantity to his breakfast; and if he dined and breakfasted in the same style each day during the breeding season, it is difficult to estimate the expense of his keep. Such is the amount of loss of impregnated roe in one morning from a trifling fish; what must it then be throughout the season from the various enemies that it has to encounter!" Facts of this kind are the strongest arguments in favour of the breeding and bringing up in ponds, where food is plentiful and foes are few.

Mr Young, too, informs us regarding the voracious habits of the common river-trout. He has caught numbers during the spawning time, but never found one of them that was not full of swallowed ova. He adds, that their destruction is not confined to the ova, but that, as soon as the spawning process is over, they attack the fry of the river, and continue to feed on them until they take their departure to the sea. As an experiment, he put into a pond, one fine evening, along with a trout of not more than half a pound in weight, a dozen fine smolts of five inches long. When the pond was examined next morning, it was found that the whole dozen were devoured. Mr Young entertains rather peculiar, but in many respects, we think, well-founded views, regarding another supposed enemy of salmon. He thinks that otters, owing to the vast quantity of trout they kill, should be encouraged as much as possible in all salmon rivers, and is of opinion that these cunning creatures seldom kill salmon, and do so chiefly at a chance time, when the lochs and pools are shut up by frost, and they are induced to prowl into a still open stream. We know not exactly how this may be, but we remember distinctly more than once finding a good cut, consisting as usual of the caudal half, of grilse or salmon, left by the otter on the banks of northern rivers. "This animal fishes for sport often when food is not required, and when he falls in with a well-stocked pool he leaves dozens of trout upon the bank unbroken, which he never returns to eat; for when the river is open there is no difficulty of procuring plenty more, and at a cheap rate. And on the whole, when all circumstances are taken into consideration, in place of the otter being ranked among the salmon's enemies, we must give him the credit of being the first of their four-footed benefactors."

Modes of capturing salmon.

We shall conclude this portion of our subject by a brief notice of the different means employed in the capture of salmon. The principle upon which stake and bag nets are constructed is the same. Each has a lengthened arm called a leader, stretching for some hundred yards seawards of the high-water mark, and at right angles with the shore. The leader of the bag net has floats above and weights below, and conducts to an oblong bag or chamber of the same materials as to mesh, cork, and lead, but its walls are kept apart by means of anchor ropes at the quarters, and light staves a-top. Where the leader joins the bag there are openings (on the mouse-trap principle), narrowing as they recede, and admitting the salmon into the chamber, within which it may reside for a length of days without ever finding the narrow and now projecting slit by which it entered, and to which it presents its broad side as it swims around within its prison wall. These anchor nets are usually set in deep water, over rough or stony shores, upon the open coast, and are not left dry at low water. They are visited by boats at every tide, and their contents extracted. Stake nets are of greater extent, and more expensive structure. A leader of great length, composed of strong netting, supported by stakes, is stretched across a comparatively shallow shore with smooth bottom, and conducts to a staked and netted chamber, with easy though deceptive ingress. This terminal prison is often so placed as to be left dry at low water, and the fish are taken out by men entering the chamber when the water has receded.

The net-and-coble fishing is worked by one or more men in a small boat, making a semicircular sweep from the shore or bank outwards and downwards, paying out the net from the stern as they proceed. The upper end of the net continues to be held by men on shore near the point of departure, the boatmen ere long land again, and the two terminations of the net being brought together, the ground rope with its sinkers rather in advance of the surface one with its floats, the whole is drawn upon the shallow shore; the fish, if within range, being inclosed in a wall of net-work on either side, and finally captured in the purse-shaped form which the middle portion of the net assumes when it impinges on the shore. Each salmon as it emerges from the water gets one or two taps on the head with a stout stick, to put an end to any further contention or dubiety as to its ultimate destination. Lastly, *cruives* are traps constructed of

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[1] If the increasing deficiency of salmon could be distinctly traced to or connected with the great increase of sea-trout, we should not hesitate to regard the advent of that decidedly inferior fish as a disadvantage, but if it is not in any way the cause of the destruction or disappearance of salmon, then, of course, its own abundance being admittedly of considerable value, must counterbalance rather than occasion the loss.

Irish salmon-fisheries.

stone walls set across a river with an intermediate chamber of wooden spars, into which salmon may enter, but from which there is no escape.

We shall now advert to a very important subject,—the salmon-fisheries of Ireland. Of these there has as yet been no proper historical or other exposition, and our own limited space, even if we possessed the requisite knowledge, would not here admit of our attempting to fill that great hiatus. All we can do is, to present a few miscellaneous notices, gathered from recent and authentic sources, such as the Reports and Correspondence of the Irish Board of Works.[1]

It appears that the salmon-fisheries of Ireland are to a far greater extent public property than those of Britain; and the public in Ireland, to a corresponding extent, exercise the common-law right of fishing in the estuaries and tide-ways. In Scotland there is a vastly greater amount of private rights, mile after mile of estuary and sea-coast being leased, and rents paid to individual proprietors. It is not so in Ireland—the exclusive individual or "several" fisheries there being few and exceptional; and for this reason it is probable that a different mode of legal regulation is required. Although royal grants of Irish fisheries were given from an early period, the royal prerogative was chiefly exercised by our James VI., who, on ascending the English throne, seems to have carried up with him the Scotch national view of the fishing franchise. Many of the *weirs*, though since transferred by patents to other parties, owe their origin to the church, in other words, they were encroachments by priors and abbots on the "King's Rivers." In the year 1537, when "coming events cast their shadows before," and the advent of the Reformation induced inquiry into the possessions of the monastic establishments, four high commissioners were sent over to Ireland to inquire into and reform abuses. It appears from a manuscript in the British museum (quoted by Mr Hore), that a jury of the city of Kilkenny presented, that "Item, the prior of Inystoke, the abbot of Jerypont, and divers others dwelling nere unto the ryver, doo make and set such weares from banke to banke in the same ryver, from Inystocke unto the mountayne of Bleme, that no ferye ne bote may have their course." Accordingly the act of 28th Henry VIII. was passed, reciting that "where at all times necessarie boates, scowtes, wherries, coltes, and other vessels, have been used to passe and repasse in the king's rivers of the Barrow, the Noyre, the Suyr, and the Rie, ... yet now of late divers wilful persons, having no respect to the premises, but more rather to their own wilfulnesse, singular commoditie, and benefite, have in divers places made such wires, purpressures, ingines, strictes, and other like obstacles, that by no means any boates, &c. can conveniently passe, and through which the salmon frie be cleerly destroyed, contrary to the effect and purport of the statutes therein provided;" and it was then enacted, that any person in company with the sheriff, or seneschal of the neighbouring shires, might ***prostrate and break down*** all such obstructions. It was also declared that a convenient gap for passage was to be made in every mill-dam.

"A remarkable feature," observes Mr Hore, "in the history of the river fisheries of Ireland is the amount of property obtained in them by the clergy, and by monastic foundations. Their claim, whether founded on that of the church of St Peter, or for the sake of enhancing their power in capturing an article of food, the use of which is enjoined by their creed, seems to have been universally recognised, whether on the part of the crown, the nobles, or the people; and to have occasioned the frequent establishment of those means forbidden by the laws, solid wiers or dams constructed across the entire bed of rivers, on the banks of which the seats of the church were more numerous than in any other country in Christendom."—*Inquiry, &c.*, p. 11.

Irish salmon-fisheries.

Ireland derives advantage, so far as her salmon-fisheries are concerned, from the comparative absence of great commercial cities, which so often injure the rivers on the banks of which they stand; and many of the tributary streams being clear and rapid, with a gravelly bottom, are well fitted for the production of these fine fish. The majority of the English streams are too slow and silent in their courses, are often artificially obstructed, and labour under disadvantage from the increase of civilization, which is against the superabundance of all creatures, of whatever kind, that require to be left in a great measure in a state of nature. The ancient Irish traditions point to the number of fish in the *invers* or estuaries; and it is characteristic of the country that the warrior Finn MacCool was *killed* by a fisherman of the Boyne *with his gaff.* His father-in-law, the monarch Cormac MacArt, was choked by the bone of a salmon. It is recorded in a tract on the O'Sullivan family, in the library of the Royal Irish Academy, that Mac Fineen Duff of Ardee was in use to receive L.300 per annum from the Spaniards for the liberty of fishing in the river of Kenmare. The value of some of these Irish fisheries, as producing an export trade, may be deduced from the *soubriquet* of O'Donnell, chief of Tyrconnel (now Donegal), who was called in Spain "the King of Fish," in consequence of the quantity imported in exchange for wine. The poet Spencer, in his *State of Ireland*, after bewailing the "lamentable desolation" and "utter waste" brought by civil war upon the province of Ulster, breaks forth into praises of the land:—"And sure it is yet a most beautiful and sweet county as any under heaven, being stored throughout with many goodly rivers, replenish'd with all sorts of fish most abundantly, sprinkled with many very sweet islands, and goodly lakes, like little inland seas, that will carry even ships upon their waters." "And lastly, the heavens most mild and temperate." In his *Faerie Queen* he takes note of many a river—of

> "The goodly Barrow, which doth hoord
> Great heaps of salmons in his deepe bosom."

And the—

> "Fair Suir, in which are thousand salmons bred."

The great poet also describes the "fishy fruitful Ban;" and, according to Pennant, 320 tons of salmon were taken at Coleraine in the year 1760.

There is no doubt that the great Irish rivers, with their numerous tributaries, if managed with judgment and assiduity, might be made of high commercial value. The Waterford estuary, though supplied by a less area than the Shannon, is the most important salmon-fishing in Ireland, as its entrance is not injured by a weir. We have no river in Britain comparable in capacity to "the spacious Shenan, spreading like a sea," and continuing open for boat-work, with short exceptions, for upwards of 200 miles above its entrance into the Atlantic.[2]

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[1] Mr Wakefield takes some note of these fisheries in his *Account of Ireland, Statistical and Political*, 2 vols. 4to, 1812. Sir Charles Morgan has compiled an *Historical Sketch of the British and Irish Fisheries.* Mr John Finlay has given us a *Treatise on the Game and Fishing Laws of Ireland*, in 1827; and some useful information will be found in Mr Herbert Francis Hore's *Inquiry into the Legislation, Control, and Improvement of the Salmon and Sea Fisheries of Ireland*, published in 1850.

[2] The following table gives the areas of the catchment basins from which the principal Irish rivers and their tributaries derive their

Irish salmon-fisheries.

But for the weir at Limerick, the Shannon would be navigable for some distance above its site. The tide rises to a height of 12 feet on either side. The weir is made of stone piers, extending across the river like those of a bridge, and lath-work is stretched securely from pier to pier at the western side, or that on which the salmon ascend from the sea. To every alternate pair of piers there is lath-work affixed at the eastern side also, so as to inclose a complete chamber. There is an aperture for the salmon to get in, but none to let them out. Between the other piers there is no passage, so that when the salmon push their snouts against the lath-work they are forced to grope their way alongside till they get into "chambers," of which they have a short lease, though one for life. This weir stands continually, night and day, during the fishing season. It now has in its centre the *mona-rea* gap, or queen's share. Up to the winter of 1825–6 this obstruction was so formed that no salmon could pass, and it had not even the "middle passage" required by statute. It was carried away by the floods, and the lessee of the corporation of Limerick replaced it by the present contrivance. (See *Dublin Review*, vol. xi., p. 387.) Although the corporation had at one time claimed the exclusive fishing of the Shannon for a distance of 63 miles from their weir above the city, to the river's junction with the main sea (as granted by Queen Elizabeth), they afterwards restricted their claim from the "great Lax-wier, down the river, to a place examined by the viewers," namely, a castle near Cratloe-more, which is a distance of three or four miles westward on the river, and which has been but recently ascertained as the boundary. On this reservation the right of fishing was ruled in their favour. We believe its commercial value is much decreased. It formerly realized in certain seasons L.2500 a-year. At an after period (though before the introduction of stake nets at the mouth of the estuary) it still yielded an annual rent of L.1150. The lease of 1813 was for L.800 a-year, and the present contract (dated 1834) is for L.300 only, with a clause of surrender.

In all fishing questions there seems a tendency to partizanship. The word *rivalry* is supposed to be derived from *rivalis*, belonging to a bank. We believe that the legal rights of the corporation of Limerick to this great weir, whether by patent or prescriptive title of many hundred years old, cannot be questioned; but the obstruction it offers both to a free run of fish, and to the still more important purposes of navigation, is undoubtedly a crying evil, and one which ought to be lessened by every lawful means. It now stretches diagonally across the river, where the breadth of the stream is 1141 feet, and has only a single central opening, where, in summer, in consequence of a neighbouring bank, the water is so shallow, that a keel boat drawing only a few inches cannot pass upwards. It is built of stones, bound together by upright posts of timber, and does not quite touch the banks on either side.

There is no doubt that in various parts of Ireland stake nets and fixed weirs have, in opposition to the express provisions of the act of parliament, been erected in improper places, and even worked during illegal times. They have sometimes been re-constructed by the same parties after prosecution and conviction. In one instance of a very valuable salmon fishery, iron spikes were found so placed across the "free pass," or queen's share, as to prevent all upward migration; and in another case an endeavour was made to defeat the object of the statute enforcing that open space, by placing glaring substances within it, and particularly a huge uncouth figure *in the form of a crocodile*, to frighten the fish from going farther.

Irish salmon-fisheries.

Although not a few of the fishing privileges in Ireland have the sanction of a very high antiquity, many of the prescriptive claims to the powers exercised are of a more or less doubtful nature. The prevailing belief in Ireland is, that the law as it now stands (5th and 6th Vict., cap. 106, 1842) is in opposition to Magna Charta, and the common-law right. It has, in fact, been sometimes so declared by the judges, who have laid it down that notwithstanding that act gave permission to parties to erect Scotch weirs where the river was more than three-quarters of a mile wide, yet that neither that law nor any other can or does interfere with the common-law right, which is this, that no man can put up an obstruction, either to navigation, or to the passage of fish, in the king's highway, or in the tide-way. "With regard to the other portion of that clause which says that a person who has maintained a Scotch weir over twenty years, where the river is not three-quarters of a mile wide, shall be entitled to fish that weir, there again the judges have declared that that is illegal, inasmuch as it is a fixed engine, and an obstruction both to navigation and the passage of fish; and although the act of parliament does in a certain degree legalize it, yet it does legalize it against the common law of the land." (Evidence of the Earl of Glengall, *Report of Select Committee* in 1849.) There is no doubt that after the passing of the act of 1842 a great increase of fixed engines followed. The 22d section of that act permits the erection of fixed engines within one mile on either side of the mouth of a river, where the channel of the tideway is more than three-quarters of a mile wide at low water of spring tides, by persons not previously possessed of a "several" or exclusive fishing, either inwards or outwards of the mouth of a river less than half a mile wide. The exact position of what is to be deemed the "mouth" of a river, is to be defined by the commissioners. Their task is neither easy nor enviable.

Lord Glengall stated, in his evidence before the Commons' committee of 1849 (*Report*, p. 150) that great advantage would arise to the revenue of Ireland from the removal of obstructions in the rivers, and the suppression of poaching; and for this reason, that the moment the upper proprietors find that the fish ascend the river in the open season, and that they have a direct interest in protecting the breeding fish, they will protect them, just as they would their sheep or bullocks; but at present they feel little interest in the breeding fish, as those in good condition are "all taken by the Scotch weir owners." His lordship further informs us, that before the introduction of the Scotch weirs the Suir was, without exception, the best salmon river in Ireland. Fine fish, weighing 18 and 20 pounds, frequently ascended as high as 55 miles above Waterford; but soon after the Scotch system commenced very few salmon got up the river except during some heavy

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supply of water. It is taken from Sir Robert Kane's *Industrial Resources of Ireland*, and was chiefly furnished by W. Mulvany, Esq., Commissioner of Drainage:—

	Total basin, square miles.		Total basin, square miles.
Shannon	4544	Slaney	815
Barrow, Suir, and Nore (Waterford)	3400	Lee	735
Erne (Ballyshannon)	1585	Liffey, Dodder, and Tolka	568
Foyle (Derry)	1476	Blackwater (Armagh)	526
Galway Waters	1374	Mayne and Inny (Killarney)	511
Bann, Upper and Lower (Coleraine), and the Main	1266	Feale and Gale (Listowel)	479
Blackwater, county Waterford	1219	Roughty (Kenmare)	475
Boyne and Blackwater, in Meath	1086	Bandon	228
Moy	1033	Lagan (Belfast)	227

Irish salmon-fisheries.

floods. The Suir River Preservation Society was afterwards instituted, and as it was not only well conducted, but "as many as 27 of the Scotch weirs were prostrated," the fish not only ascended the river again for 55 miles as they used to do thirty years before, "but to our great astonishment we last year captured many fish of 30 and 25 pounds weight, 45 miles from the sea. Now, no man had ever seen a 30 or 25 pound fish for 30 years in those waters before." The case of the Lake of Killarney is also a curious one as regards the effects of fixed engines near the mouths of rivers. In former days the lake was full of salmon, and vast numbers of people resorted to that beautiful region for the sake of angling. It is chiefly the property of Mr Herbert of Mucross, and Lord Kenmare. For many years after the erection of Scotch weirs at the mouth of the river, scarcely any salmon ascended to the lake; but when the act of 1842 was passed, the proprietors of the lake were instructed how to proceed against the parties holding the weirs, and six of them were *prostrated*. One still remains, but, in spite of it, the lake is now remarkably well supplied with salmon.

The Irish salmon-fisheries are regulated chiefly by the act 5th and 6th Vict., cap. 106. It was passed in 1842, for the purpose of consolidating and amending the others then in force, and repeals all former acts relating to the salmon-fisheries of that country. The commissioners of the board of works are thereby constituted commissioners for the execution of the act, and have had conjoined with them two inspecting commissioners of fisheries. They are intrusted with a variety of important duties, and can make bye-laws for the alteration of close time, and its variation in different districts. The main object of the act of 1842 was to induce the capture of the largest quantities of fish, in the best condition, during the open season, consistently with the increase of the breed. It fixed a uniform close time, from the 20th of August to the 12th of February, to come into operation after the 1st of January 1844. It was not attempted to be enforced until after the 20th of August 1844, and was in truth but little attended to for some time afterwards.

In a later act, that of 9th and 10th Vict., cap. 14, which was prepared and submitted to parliament, in order to carry into effect certain regulations regarding close time, a clause was introduced in its passage through the House of Commons, whereby eight counties (viz., Antrim, Tyrone, Donegal, Londonderry, Mayo, Fermanagh, Leitrim, and Sligo) were exempted from the operation of the law.[1] This produced great confusion, and the Irish commissioners have since had applications from almost all those counties for the extension to them, *by bye-law*, of the benefits of the former close time, from which they were excluded by the clause just referred to.[2]

The annexed tabular view (see page 621), for which we are indebted to the kindness of Thomas F. Brady, Esq., one of the inspecting commissioners of the Irish fisheries, exhibits the exact state of the close-times of the various districts up to August 1855. We believe that some of the changes indicated in the table have been made rather with a view to meet the wishes of the individuals interested in the localities, than from a conviction on the part of the commissioners of their absolute expediency. But as the commissioners have the power, under the 35th section of the act, to rescind any order for change of season after three years, they are probably induced to allow persons to have their own way for a time, and not a few are said to have become convinced of their error from practical experience. The laws on the subject of the annual or weekly close seasons in Ireland are now very stringent, and the penalties for their infringement heavy. Assuredly they ought to be strictly enforced, because any wide departure from the legal principle is the more to be regretted in a country where so large a portion of the salmon and trout fishing is, by law, public property.

Irish salmon-fisheries.

For some seasons after the passing of the act of 1842, large captures ensued, and thus the practical operation of the amended law was to produce improvident destruction—nothing in the way of counteracting remedies being used to replenish or keep up the stock. Voluntary contributions having failed in their sufficiency to afford protection and remove obstructions, the act of 11th and 12th Vict., cap. 92, was passed (in 1848), authorizing assessment upon engines used in fishing, in order to create a fund for the purposes of preservation, to be administered by local boards of conservators, elected on a broad basis. This act did not come into operation till 1849, but it is now believed to be producing the desired effect. It also empowers the Irish board of works to divide the "Green Isle" into districts, and the recent arrangements will be seen from the annexed table.

The same variations take place in the Irish rivers as in those of Scotland, and the same somewhat contentious complaints are made by opposing parties against each other. The natives of the more upland streams bewail the unsparing and irresistible captures by sweep nets and fixed engines, while those who rejoice in, because they benefit by, the latter, are shocked at the unprincipled poaching and general want of protection which prevail in places where the spawning beds abound. The select committee on the fisheries of Ireland (1849) conclude their report by desiring "to record, once for all, their decided conviction, that the wholesale and wasteful destruction of the breeding fish and fry has materially injured the inland fisheries, and has excited and kept alive much local discontent, and demands the immediate attention of parliament, in order to the adoption of such alterations in the existing law as may be found expedient." In the minutes of evidence taken by that committee, Mr Ffennell, one of the inspecting commissioners, while referring to the advantages arising from a private protective association, and when asked, "Why did your association cease to exist?" replies, "Many persons found that they were going to expense, and taking a great deal of trouble in protecting the fish for the persons in the tideway, not one of whom would subscribe one farthing." Being asked, "to whom do you allude when you say 'persons in the tideway?'" he answers, "all the persons, the river owners, the cot fishermen, and every class of persons in the tideway; we found that we could get no subscription whatever from them, and that we were doing it all at our own expense, and that others were making the harvest. The large benefit of our protection must be to the tideway people, and it is there that the commercial value of the fish must always exist."

[1] An odd effect of these exceptions was that, for example, during a portion of the season, it was illegal to fish in *one* side of a river and bay in the county of Mayo, while it was legal to fish in the *other* side of the same river and bay in the county of Galway.

[2] The Irish Commissioners are appointed for the execution of the Fishery Acts by the 2d sect. of the 5th and 6th Vict., cap. 106, and the 2d sect. of the 11th and 12th Vict., cap. 92, and are empowered by the 33d section of the former, and 39th section of the latter act, to alter the close seasons in any river or district upon inquiry made and proof presented that such alteration is expedient. The 3d sect. of the 11th and 12th Vict., cap. 92, also directed the Commissioners to divide Ireland into districts, which they have done accordingly. That section, and the 6th sect. of the 13th and 14th Vict., cap. 88, conferred the power on the Commissioners to alter such districts, and to fix other boundaries, and to subdivide them as they saw fit. The districts of Bantry, Westport, and Londonderry have thus been subdivided, and so many alterations have been made in the close times (tending to uniformity) that Sligo, Fermanagh, and Leitrim are now the only excepted counties. In addition to these changes, the Commissioners have been called upon by persons interested in the fisheries of several districts to alter the seasons as fixed by law, and they have accordingly done so in the districts of Killarney, Limerick, Wexford, and Cork. Our tabular view will show these details distinctly.

Table showing the Close Seasons for Salmon and Trout in the different Districts in Ireland, as fixed by Statute Law, or the Order of the Commissioners.

No. and Name of District.	Counties or Parts of Counties comprised within District.	Principal Rivers in District.	Close Seasons for Net Fishing. By Statute Law. Tidal.	Close Seasons for Net Fishing. By Statute Law. Fresh Water.	Close Seasons for Net Fishing. By Order of the Commissioners. Tidal.	Close Seasons for Net Fishing. By Order of the Commissioners. Fresh Water.	Close Season for Rod Fishing, Single Rod and Line. Tidal.	Close Season for Rod Fishing, Single Rod and Line. Fresh Water.
1. Dublin	Dublin, Kildare, Wicklow.	Swords or Meadow Water, Tolka, Liffey, Bray, Vartry, Rathnew.	Sep. 1 to Jan. 31.	Sep. 1 to last day of Feb.	—	—	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
2. Wexford	Wicklow, Carlow, Wexford.	Slaney, Baunow, Blackwater, Potter, Avoca, Courtown or Owenavarra, Sow.	Do.	Do.	Sep. 29 to last day of Feb.*	Sep. 29 to last day of Feb.*	Sep. 29 to March 1.	Sep. 29 to March 1.
3. Waterford	Queen's, King's, Kildare, Kilkenny, Tipperary, Waterford.	Suir, Nore, Barrow, Mahon, Stradbally, Dolligan, Colligan.	Do.	Do.	—	—	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
4. Lismore	Cork.	Blackwater, Bride, Fuinisk.	Do.	Do.	—	—	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
5. Cork	Cork.	Lee, Bandon, Carrigalim, Arrigadeen, Owenabuoy.	Do.	Do.	Electoral Div. B. Sep. 1 to March 1.	Electoral Div. D. Sep. 1 to April 1.	Elect. Div. A. Sep. 29 to Jan. 31. Elect. Div. B. Sep. 1 to Mar. 1.	Elect. Div. C. Sep. 29 to Mar. 1. Elect. Div. D. Sep. 29 to Apr. 1.
6[1]. Skibbereen	Cork.	Owenahinchy, Roury, Ilen, Leamavadarra, Ballydehob.	Do.	Do.	—	—	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
6[2]. Bantry	Cork.	Ouvane or Ballylicky, Four Mile Water, Snave, Glengariffe, Adrigole, Maganigan, Dounemark.	Do.	Do.	—	—	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
6[3]. Kenmare	Cork & a portion of Kerry.	Sneem, Sheen, Roughty, Blackwater, Clonee, Owenshagh, Croanshagh.	Do.	Do.	—	—	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
7. Killarney	Kerry.	Laune, Maine, Carra, Curraun, Juny, Fartagh or Valentia, Carhan, Ownagare, Beagh.	Do.	Do.	July 31 to Jan. 1.	May 31 to Jan. 1.	July 31 to Jan. 1.	Sep. 30 to Jan. 31.
8. Limerick	Limerick, Clare, Westmeath, Longford, King's, Roscommon, and small portion of Leitrim.	Shannon, Cashen, Feale, Geale, Fergus, Maigne, Askeaton, Deel.	Do.	Do.	Aug. 13 to Feb. 11.	Aug. 13 to Feb. 11. Electoral Div. C.B. Aug. 13 to May 1.	Aug. 13 to Feb. 11.	Sep. 15 to Feb. 11.
9. Galway	Galway, and portion of Clare.	Corrib, Furboe, Spiddle, Costelloe, Ballinahinch.	Do.	Do.	—	—	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
10[1]. Ballinakill	Galway, Mayo, and part of Clare.	Clifden, Ass or Errive, Delphi, Renvill.	Aug. 20 to Jan 31.	Do.	Sep. 1 to Jan. 31.	Sep. 1 to last day of Feb.	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
10[2]. Bangor	Mayo.	Newport, Burrishoole, Ballycroy, Munhim, Owenmore, Glenamoy.	Do.	Do.	Sep. 1 to Jan. 31.	Sep. 1 to last day of Feb.	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
11. Ballina	Mayo, and part of Sligo.	May, Owenmore, Easkey, Rathfran.	Do.	Do.	—	—	Aug. 20 to Jan. 31.	Aug. 20 to Jan. 31.
12. Sligo	Sligo.	Sligo or Garogue, Ballisodare, Dromore, Drumcliff.	Do.	Do.	—	—	Aug. 20 to Jan. 31.	Aug. 20 to Jan. 31.
13. Ballyshannon	Donegal, Fermanagh, Cavan, and Monaghan.	Erne, Bundrowes, Eask, Inver, Glen, Brackness, Ballydor.	Part Aug. 20 to Jan. 31. Part Sep. 1 to Jan. 31.	Part Aug. 20 to Jan. 31. Part Sep. 1 to last day of Feb.	—	—	Part Aug. 20 to Jan. 31. Part Sep. 29 to Jan. 31.	Part Aug. 20 to Jan. 30. Part Sep. 29 to March 1.
14. Letterkenny	Donegal.	Leenane, Gweebarra, Rathmelton, Farran, Buncrana, Ardara, Owenoocker, Owenea.	Aug. 20 to Jan. 31.	Aug. 20 to Jan. 31.	Aug. 1 to Dec. 31.	Aug. 20 to last day of Feb.	Aug. 1 to Dec. 31.	Sep. 1 to March 1.
15[1]. Londonderry	Londonderry, Tyrone, & portion of Donegal.	Glen Foyle, Roe, Faughan.	Part Sep. 1 to Jan. 31. Part Aug. 20 to Jan. 31.	Part Sep. 1 to last day of Feb. Part Aug. 20 to Jan. 31.	Sep. 1 to Jan. 31.	Sep. 1 to last day of Feb.	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
15[2]. Coleraine	Londonderry, Tyrone, Armagh, Antrim, Monaghan.	Bann, Maine, Blackwater.	Part Sep. 1 to Jan. 31. Part Aug. 20 to Jan. 31.	Part Sep. 1 to last day of Feb. Part Aug. 20 to Jan. 31.	Sep. 1 to Jan. 31.	Sep. 1 to last day of Feb.	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
16. Ballycastle	Antrim.	Bush, Ballycastle, Cushendum, Cushendal, Glenariff, Glenarm, Favre or Larne.	Aug. 20 to Jan. 31.	Aug. 20 to Jan. 31.	Sep. 1 to Jan. 31.	Sep. 1 to last day of Feb.	Sep. 29 to Jan. 31.	Sep. 29 to March 1.
17. Drogheda	Louth, Meath.	Boyne, Dundrum, Blackwater, Kilkeel, Castlewellan, Annagassen, Nannywater.	Sep. 1 to Jan. 31.	Sep. 1 to last day of Feb.	—	—	Sep. 29 to Jan. 31.	Sep. 29 to March 1.

* But for Fixed Nets 14th September to last day of February.

Irish salmon-fisheries.

The attention of the public, however, has recently been much directed towards Ireland and its capabilities, and an interest in the salmon-fisheries has evidently been on the increase from year to year. We believe the more they are considered the higher will their importance be appreciated as a branch of industrial occupation.

"And although," says Mr Ffennell, "an alleged decrease must be admitted to have occurred, yet some exaggeration prevails on the part of those persons whose interests have been diminished in value by the changes which have recently taken place in the capture of fish, and some miscalculations also arise in consequence of the more rapid and extended flow by which the tide of commerce, through the agency of steam, conveys the produce from local to distant markets. Proprietors of several fisheries sometimes judge the question of supply by the amount of their own capture solely, forgetful of, or misinformed on, the aggregate quantity captured by the many who fish outside, and which is there taken. The consumers in the principal towns, who, before the extension of railroads and steam navigation afforded means of cheap and quick transit to other markets, and before the facility of obtaining ice for its preservation at a reasonable charge existed, obtained salmon at low prices, complain of high prices, advance it as a test also of diminished supply, forgetting or overlooking the fact of the large quantity which is daily transmitted from their immediate vicinity to more remunerating customers in distant places. The grounds of disappointment and miscalculation are evident with regard to these classes, while others, who have been restrained by the enforcement of the law from undue interference with public as well as private rights, pronounce the alleged decrease in the salmon-fisheries of Ireland to be progressive in proportion as legislation has advanced for the purpose of meeting the evils complained of; and although the latter class may find some discontented persons, from selfish motives, ready to join in this too summary mode of disposing of the question, very many must conclude that it tends to mislead rather than induce a useful or disinterested discussion of the subject. Salmon having attained a price in the market as a luxury only available to the wealthy portion of society, and this increased value having stimulated a corresponding energy on behalf of the public to procure it for such profitable disposal, an improvident desire of over-capture has for some years been induced, which we believe to be the main point necessary to guard against and restrain. The ingenuity of man has also increased the efficiency of the means of capture, and the legislature having sanctioned the use of engines, under certain limitations, before restrained, at the same time, however, giving increased powers to protect; whilst the power to take has been injuriously applied, the intended equivalent of better protection has been too much neglected."—*Report*, 1852, p. 237.

Of course, the same nefarious practices prevail among the natives of the sister isle as with ourselves. The habit of "burning the water" is common in many of the wilder districts. The excitement of the sport, in addition to its productive nature, may be viewed as affording some excuse, but none can be offered for that deadly and altogether indefensible act of "poisoning" which is not seldom had recourse to. This is sometimes practised in Scotland by means of lime, a small quantity of which will destroy every fish in a pool. An equally opprobrious procedure is followed, too, in the county of Kerry. There, and elsewhere in Ireland, a species of spurge occurs in woods, and is called *Euphorbia hibernica*. It has a white juice, which may be extracted by pounding in a tub. If some of this liquid is thrown into a river when the water is low, the fish are killed for a considerable distance, and soon show themselves by floating on the surface. They are, unfortunately, not thereby rendered unfit for food; and when the country people hear that a river has been "poisoned," they assemble on its banks to share the spoil. Poaching is also carried on to a great extent, and, according to one authority, this has been greatly increased by the diminution of salmon during the open season.

"I remember," observes Mr J. D. Croker, speaking of the Blackwater, "when the river was so well stocked that the lower classes were universally permitted by the gentry to angle in every place without any obstruction. We found that by so doing we enlisted them, I may say, as bailiffs to protect the breeding fish in the winter, and that we had a sufficient *quid pro quo*. By and by, when their weirs were closed, and their mill barriers were shut up, the salmon decreased in the river in numbers, and the consequence was then, that the gentleman fond of angling prohibited, to a certain degree at first, those men who used before to be permitted to fish; and finally, I may say, they found there were so few salmon that they kept them for themselves, and in many places they were not allowed to fish where they formerly enjoyed the sport; the consequence was, that these fellows, when they could not get them in the summer, turned to poaching in the winter. When there is a flood in the river, and the weirs are open in the winter, they come up in thousands, and the destruction is beyond anything which you can conceive. The landed proprietors, finding that in the whole of the open season they had no fish, take no interest in preserving the spawning fish for the proprietors who have the monopolies at the mouth of the river; and I believe this to be the chief cause of the decline of salmon."—*Report from the Select Committee on Irish Fisheries* (1849), p. 36.

It is difficult to obtain actual data from which to ascertain the money value of the general salmon-fisheries of a country. In regard to those of Ireland, we observe it stated in evidence by Sir Richard De Burgo that he calculated the value of salmon caught by "every engine" (for the year 1847) to be close upon L.300,000. He had ascertained that there were L.18,000 worth caught in the estuary of the Suir, Nore, and Barrow. He put down the Shannon at L.20,000; and so on with the Lee, and other districts, however small. He applied to various parties for information regarding their own vicinity. "I then received from the same parties, as closely as they could give it to me, the number of rods, and every other engine that was used in their estuary, river, or in the entire district; and they fixed what they conceived the productive properties of the weirs, or whatever else the engine might be." It was thus that he made up his data. He regarded the above as a low estimate, and was of opinion that if some changes in the law were effected, and due protection afforded to spawning fish and fry, the Irish salmon-fisheries might be raised to the annual value of not less than L.2,000,000.

The following list, though imperfect, will show, at least approximately, the produce of the principal salmon-fisheries of Ireland, and will also indicate the names of the rivers, &c., where these occur. It was obtained in the year 1844-45, and applies to the quantities and value of that period.

Name of River.	Number of Fish, or money value, as far as could be ascertained.
1. Liffey	From 5000 to 7000 salmon, of an average weight of 7½ lb., was the produce of 1844; the average price was from 8d. to 1s. per lb.
2. Owenavarra	About L.140.
3. Slaney	About L.2000.
4. Barrow, 5. Nore, 6. Suir	About L.17,000 or L.18,000.
7. Blackwater	From L.3500 to L.4000.
8. Lee { Upper, Lower }	About L.1900.
9. Bandon	About L.170.
10. Ilen	About L.90.
11. Snave and Ballylicky.	About L.180.

Irish salmon-fisheries.

Irish salmon-fisheries.

Name of River.	Number of Fish, or money value, as far as could be ascertained.
12. Blackwater	About L.60.
13. Roughty; 14. Curraan; 15. Eenagh; 16. Carra; 17. Laune; 18. Maine	About L.7000.
19. Cashen	About 1500 salmon.
20. Feal	
21. Shannon { Upper... Lower... }	About 6000 salmon and 24,000 peal.
22. Corrib or Galway	4221 salmon; 10 tons average yearly produce.
23. Spiddal	About 400 salmon.
24. Costello	
25. Ballinahinch	5114 salmon, 34,747 lb.; 14,385 lb. trout, average yearly produce.
26. Benoyle Fishery	About 10 tons annually.
27. Delphi	610 salmon, 3847 lb.; 606 trout, 1417 lb., average yearly produce.
28. Errive, or Ass	60 salmon, last year's produce.
29. Killieries	Between L 300 and L.400.
30. Bellclare	L.18 or L 20 a-year.
31. Newport	In 1845 the produce was 8 tons salmon, and 3 tons trout.
32. Burrishoole	
33. Ballycroy	1841, 34 tons salmon; 1843, 21 tons; 1844, 24 tons.
34. Owenmore	About L.50.
35. Munhim	Between 2 and 2½ tons.
36. Glenamoy	23 cwt. was last year's produce.
37. Moy	
38. Easky	6 tons, 13 cwt., 3 qrs., 20 lb. last year.
39. Ballysadare	About 300 salmon yearly.
40. Sligo	7 tons, 7 cwt., 3 qrs., 2 lb. average.
41. Drumcliff	About L.30.
42. Bundrowes	9 tons, 18 cwts., 1 qr., 2 lb.
43. Erne	
44. Inver	1844, 753 lb. salmon, 2185 trout; 1845, 1242 lb. salmon, 1106 lb. trout.
45. Owentorker	
46. Owenea	
47. Clady	
48. Lacagh	1116 salmon, 7712 lb. average.
49. Rathmelton.	Average 9625 lb. salmon.
50. Foyle	About 82,000 salmon.
51. Roe	
52. Bann	51 tons, 1 cwt., 17 lb., average of six years.
53. Bush	10 tons, 6 cwt., 1 qr., 10 lb., average of four years.
54. Glyde and Dee	About L.600.
55. Fane	Between L.20 and L.30.
56. Boyne	

We anticipated the power of obtaining some detailed and accurate information regarding the pecuniary value of the Irish salmon-fisheries from the returns of the assessment laid upon them by the Poor Law Act. That such assessment must, however, be carried on in a very lax and careless manner, is evident from the fact that their total rated value, as laid before the select committee of the House of Commons in 1849, was only L.12,366, and even in that sum were included a few oyster and eel fisheries. It appears that the public fisheries, which comprise the chief portion of the tidal rivers, are not rateable. It must also be borne in mind that the rating is only upon what is fixed or stationary—no floating nets, draught-nets, sweep-nets, or such like, being charged at all. There are even many fixed engines not rated; because those who work them in the tideways do not do so as having any private right, thus gaining the benefit of a private property, but avoiding the poor-rate on the ground that it is public. But whatever may be the cause, there is no doubt of great neglect in the true valuation of the Irish fisheries under the poor law. The stake-nets, or Scotch weirs as they are called, are taxed at a certain sum whatever may be their productive value, and many of them are not rated at all.[1]

In the Report of the Commissioners for 1836, we have the following table, showing the produce of the Foyle fishery for 16 years prior to the introduction of the stake-nets:—

Year.	Number of Fish.	Year.	Number of Fish.
1808	14,837	1816	17,624
1809	14,413	1817	16,644
1810	17,145	1818	17,860
1811	9,601	1819	23,334
1812	19,285	1820	18,930
1813	14,375	1821	11,490
1814	18,434	1822	22,816
1815	20,630	1823	20,384
		Gross produce of 16 years	277,802

This gives an annual average of 17,363. In the same report we have another table, showing the take of the same fishery for 9 years preceding 1836, during which years the stake-nets were in full operation.

In 1827, the number of salmon taken was, in

		Stake-nets,	13,911	
...	...	Draught-nets,	32,090	
				46,001
1828,	...	Stake-nets,	13,070	
...	...	Draught-nets,	37,536	
				50,606
1829,	...	Stake-nets,	9,770	
...	...	Draught-nets,	23,000	
				32,770
1830,	...	Stake-nets,	30,957	
...	...	Draught-nets,	35,096	
				66,053
1831,	...	Stake-nets,	23,267	
...	...	Draught-nets,	39,293	
				62,560
1832,	...	Stake-nets,	31,497	
...	...	Draught-nets,	32,950	
				64,447
1833,	...	Stake-nets,	20,757	
...	...	Draught-nets,	29,580	
				50,337
1834,	...	Stake-nets,	20,575	
...	...	Draught-nets,	33,173	
				53,748
1835,	...	Stake-nets,	22,344	
...	...	Draught-nets,	33,562	
				55,906
Gross produce in nine years—		Stake-nets,	186,148	
		Draught-nets,	296,280	
			Total,	482,428

Annual average, 53,603.

[1] The following is the scale of license duties for each engine, net, instrument, or device used in salmon, trout, pollen, or eel-fisheries in Ireland:—

Single salmon rods	L.1	0	0
Cross lines and rods	2	0	0
Snap nets	1	10	0
Draft nets or seines	3	0	0
Drift nets	3	0	0
Trammel nets or draft nets for pollen	1	10	0
Pole nets	2	0	0
Bag nets	L.5	0	0
Fly nets	5	0	0
Stake nets or stake weirs (Scotch)	15	0	0
Head weir	3	0	0
For every box, crib, cruive, or drum-net in any weir for taking salmon or trout	5	0	0
For every gap, eye, or basket in any weir for taking eels	1	0	0

Other nets or similar engines, not named above, to have the license duties fixed by the Commissioners.

Irish salmon-fisheries.

In a subsequent report (1846), we have the following statement in relation to the six seasons, from 1839 to 1844, both inclusive:—

In 1839, the total number taken in the Foyle fishing was			43,181
In 1840,	...	...	59,305
In 1841,	...	...	52,582
In 1842,[1]	...	...	82,106
In 1843,	...	...	62,348
In 1844,	...	...	49,337

It appears from the preceding tables, that while the annual average of certain seasons prior to the introduction of stake-nets was 17,363 fish, the smallest number taken in any one year afterwards (that of 1839), was 43,181, of which 23,934 were taken by means of draught-nets alone, being 6571 more than the average of those nets in earlier times. It further appears, that while in 1830 the produce of both kinds of nets was 66,560, that of 1842 was 82,106; so that after fifteen years working of the stake-nets, the quantity taken by both means had increased. The report for 1836 is headed—"The product of the Foyle salmon-fisheries has increased very much within these last ten years, in consequence of the introduction of stake-nets, and an improved mode of fishing with draught-nets; also, by establishing a more vigilant and effective system of water-keeping." We doubt not that the productive powers of these fish are so great, that if the fry (parr and smolts) are effectively protected while in the river waters, a great increase of captures may be looked for. The practice of preserving the fish in ice, and the enlarged facilities of transmission by steam-boats, have no doubt increased the value of salmon in Ireland as elsewhere; and Loch Foyle being a fishery of the "Irish Society," that company is believed to have added to its protective staff, and exercised greater activity and vigilance in watching the spawning grounds, thus ensuring an increased take and a larger income.

The following particulars, which further illustrate the value of the Irish fisheries, may be gleaned from the various reports by select committees of the House of Commons (1824–25–27–36). Mr Little, one of the principal lessees of the north-western stations, stated that the fish from each of the rivers Bann, Foyle, and Moy were worth at least from L.5000 to L.6000 per annum, and in some years from L.8000 to L.9000. The sale of salmon caught in them during 1835, amounted in Liverpool to L.9000, in Manchester to L.5000, in the neighbourhood of the rivers themselves to L.1800, besides considerable consignments to Dublin, London, and Glasgow, the total being nearly L.18,000. The annual produce of the Foyle for nine years prior to 1836 was 53,603 salmon, weighing above 140 tons, and worth nearly L.17,000. The quantity of salmon shipped by Mr Little and his partner to Liverpool, from their fisheries on the Bann, Bush, Foyle, Ballina, Ballyshannon, and Port Rush, from 1808 to 1823 (including shipments for the last year to London, Bristol, Glasgow, and Whitehaven), was somewhat over 2134 tons 14 cwt., which, at a shilling per pound, made the sum of L.239,141, 3s. In some seasons the Port-Rush fishery produced 18 tons of salmon, the Bush 15 tons, the Moy, at Ballina, 100 tons, and the Ballyshannon 90 tons. When such is the value of these comparatively small fisheries, which are nothing like those of the Shannon, Kenmare, and Blackwater, it has been inferred that the value of all the fisheries from which the public are now excluded cannot be under L.500,000 a-year.[2] So plentiful were salmon at one time in the Bann, that, according to Mr Finlay, 1400 have been caught at a single haul, and 1000 at the succeeding one.[3]

Irish salmon-fisheries.

Mr Christopher Keays, who had been for twenty-two years connected with the fisheries at Killorglen on the Laune (the Killarney river), used to pay from L.5000 to L.6000 annually for the fish he bought, including the price of the Waterville fish. The prices were, for spring fish 1s. per pound, for summer fish 3½d., and for May fish 6d. He had five or six ice-houses, and did not require to import that material. He sent the fish to England packed in ice, and sometimes pickled. Got the greatest number of good spring fish in April, and of grilse in June. In the year 1834, the greatest number he got from the Carra was in December, and they were in the finest condition. "The nearer the fish to the sea the better. The fish begin to loose their curd as soon as they go up the fresh water." We shall here give the monthly produce in weight for four successive seasons.

Amount of salmon purchased at Killorglen by Messrs Keays & Ronayne for the years mentioned:—

For 1841.

November 1840	...	3,719 lb.
December 1840	...	4,233 „
January 1841	...	6,454 „
February „	...	4,584 „
March „	...	6,355 „
April „	...	8,772 „
May „	...	12,310 „
June „	...	33,317 „
July „	...	47,946 „
August „	...	16,882 „
September „	...	2,404 „
Total,		146,976 lb.

For 1842.

November 1841	...	2,412 lb.
December 1841	...	4,522 „
January 1842	...	4,120 „
February „	...	4,531 „
March „	...	2,420 „
April „	...	3,787 „
May „	...	13,972 „
June „	...	28,615 „
July „	...	55,188 „
August „	...	17,766 „
Total,		137,333 lb.

For 1843.

November 1842	...	3,789 lb.
December 1842	...	3,719 „
January 1843	...	5,318 „
February „	...	7,129 „
March „	...	5,652 „
April „	...	4,461 „
May „	...	11,398 „
June „	...	49,171 „
July „	...	61,409 „
August „	...	14,273 „
Total,		166,319 lb.

For 1844.

November 1843	...	
Dec. 13th, 1843	...	2,774 lb.
January 1844	...	4,444 „
February „	...	10,052 „
March „	...	5,330 „
April „	...	9,320 „
May „	...	19,162 „
June „	...	39,536 „
July „	...	46,477 „
August „	...	8,168 „
Total,		145,263 lb.

More than L.4000 worth of salmon were taken in the Slaney in 1842; and a Scotchman of the name of Hector, an experienced owner of bag-nets at the mouth of the estuary, stated in evidence that if properly fished and efficiently protected, it might be raised to the value of L.7000 per annum. The river Moy fishery is rated to the poor-law valuation at L.1768, 15s. a-year, although it is believed on good authority to be worth L.4000. The annual expense of protecting the Moy, Bann, and Foyle amounted to L.1500 or L.1600. There were four hundred men employed as keepers, and yet many of the tributary streams were left unwatched. The lessees complained of this expense of protection, which was a tax nearly equal to the rent. However, the amount of sales of salmon from these three rivers amounted during the preceding year to L.17,450. When the native supply of ice failed, the cost of importing that indispensable material from Norway amounted to L.1500 a-year. Prior to the year 1824 employment was given by that fishery to 800 people. In consequence of increased preservation the production rose. The annual average produce of the Foyle, for sixteen years before the introduction of stake-nets, had

[1] The season of 1842 was an excellent one for the salmon-fisheries in general. During that year nearly 110,000 grilse were taken in the lower portions of the Tweed. No season was so successful within our recollection since 1816, in which these same fisheries produced above 120,000 grilse. The year first named was excellent also in the Tay, the Kinfauns fisheries having yielded above 21,000 grilse, or nearly double the average of that time. A productive salmon season may arise from one or other of two causes, or both combined. It may depend on a preceding spawning time having been unusually favourable, or upon the weather during the season of capture having been advantageous for the working of net and coble, and the ascent of fish from the sea.

[2] *Dublin Review*, vol. xi., p. 360.

[3] *A Treatise on the Game and Fishery Laws of Ireland*, Note to p. 175.

Irish salmon-fisheries.

been 17,363 salmon, weighing about $43\frac{1}{2}$ tons. The produce for the last nine years (Commissioners' Report for 1846) had been 53,603 salmon, weighing above 140 tons; so that in addition to an increase of about fifty per cent. in the quantity taken by the draught-nets, nearly as large a take as in former years by these alone was made by the then newly introduced stake-nets. Thus the produce of the Foyle alone was raised from an average, prior to 1823, of 43 tons, to a steady return of nearly 200 tons, and in the great year of 1842 to close upon 300 tons. The numerical produce that year was 82,106 salmon. According to the evidence of the agent of the lessees, the entire produce of the river during the first year of his management was 39 tons. He commenced protecting, and three years afterwards the yearly return rose to 100 tons, and the average produce of seven years is now (evidence given in 1845) 140 and odd tons. It is stated in Lord Strafford's *Letters* (1638), that the fishery at Derry (that of the Foyle) produced to the crown in that year 240 tons of salmon, which sold at L.15 a ton, "so as I hope, the charge of getting, salting, and packing the fish, deducted, there will be cleared at least L.1400, while it was never let for above L.1000 before, so as his majesty, you see, will come by no loss the whilst." By modern protection it is again approaching the limit of its ancient produce.

Return of the quantities of raw and manufactured salmon exported from Cork by the establishment of Mr John Christopher Keays. The fisheries embrace about a mile on the Clare shore, from near Money Point to Clonderlaw Bay; and on the south, from a mile on the other side of Tarbet to Foynes, including a range of 12 or 14 miles. There are eleven stake-nets.

1842.—*Exports, extending over a period of ten months.*

	No. of Fish.	Gross lb.
Raw salmon, iced, 3811 boxes, containing...	56,937	381·116
Manufactured, 3529 kits, containing..........	15,744	102·347
Total.........	72,681	483·463

1843.—*Exports, extending over a period of six months.*

	No. of Fish.	Gross lb.
Raw salmon, iced, 2766 boxes, containing...	38,980	276·651
Manufactured, 2873 kits, containing..........	14,914	86·548
Total	53,894	363·199

1844.—*Exports, extending over a period of six months.*

	No. of Fish.	Gross lb.
Raw salmon, iced, 2330 boxes, containing...	33,815	233·061
Manufactured, 2449 kits, containing..........	11,665	69·966
Total.........	45,480	303·027

We have an abstract of the monthly supply of salmon received at the establishment of Messrs Keays and Ronayne, Youghal (Blackwater fishery). We shall here give only the totals for two years.

	No. of Salmon.	Weight. Tons.	Cwts.	Amount Paid.
1842...	14,511	33	15	L.1479 14 7
1843..............	9,823	24	17	1159 0 4

In both the above years the season commenced on 14th February. Mr Hodnett received about *one-third* additional.

The following is the gross produce of the weir and fishery of Lismore each year since 1823—odd pounds excluded.

	Salmon.	Tons.	Cwts.		Salmon.	Tons.	Cwts.
1823......	6,086	20	6	1834......	7,934	23	7
1824......	6,988	19	0	1835......	9,379	28	10
1825......	5,813	16	7	1836......	4,792	14	17
1826......	4,802	15	6	1837......	8,501	23	11
1827......	5,819	17	13	1838......	12,033	33	12
1828......	7,592	23	17	1839......	8,645	26	1
1829......	6,379	19	0	1840......	8,259	23	17
1830......	6,890	20	10	1841......	6,904	21	6
1831......	6,978	17	17	1842......	7,590	20	19
1832......	8,738	29	7	1843......	6,913	21	1
1833......	9,184	25	0	1844......	4,248	13	15

During these twenty-one years they always fished in the same manner. The return includes the entire take. They fished in the tideway, but not below Salter Bridge. The greatest run of early fish the lessee ever had was in the month of February 1844. On the opening day of that season (14th of the month), 288 fish were captured, weighing 2311 lb. The weekly close time had been strictly observed in 1843, but those conversant with the locality do not consider that the increase was produced by that observance, but rather by the fact that the Scotch weirs further down were not in fishing order. From 1823 up to the passing of the act of 1842, the close time was not strictly attended to. They used to catch in the month of December the most delicious fish of the year. This seems a parallel case to what has been stated regarding the Ness, and some other northern rivers.

The Moy presents a fair example of the good effects of protection. In 1811 half of the lease was purchased from one of the holders, but the partners were "bad friends," and one of them would not concur in the expense of watching. The quantity of fish taken that year was only 6 tons 4 cwt. This condition of affairs continued until 1815, when the lease falling wholly into the hands of the new proprietors, they immediately appointed water-keepers, and in the following year were rewarded by a take of 42 tons. Since that time, 100 tons have been killed in a single season, and the average has been 60 tons; so that an increase of ten-fold "arose from the protection afforded to the mother fish."—*Evidence*, of 1824. The Newport river affords similar and more recent testimony. After the passing of the act of 1842, Sir Richard O'Donnell, being sole proprietor of this small river in the county of Mayo, took advantage of the provisions of the act, and paid liberally for the protection of the fish. In the course of three years he raised the produce from a ton to eight tons of salmon, and three tons of white trout, for the season ending the third year.—*Evidence* in Fourth Report, 1846.

The produce of the salmon-fisheries of Ireland (as elsewhere) for 1850 was about the least upon record. We find its failure foreseen and predicted by Mr Caulfield, superintendant of the Hon. Mr Plunket's fishing in Killevy Bay, situate in a mountain district. The following letter was addressed by him to the commissioners :—

"I beg to call your attention to a letter written by me on the 4th of March 1848, in which you will find that I predicted that many persons would be disappointed in the take of salmon in 1850. The spawning season ending January 1847 was very bad from the time the salmon began to deposit their spawn. One flood was higher than another, tearing away bridges, the banks of rivers, the spawning fords, and, in some parts, covering those fords with a depth of gravel scarcely credible. Since I came here, I never saw so many floods in the spawning season. I am fully convinced then that the greater portion of the spawn were swept to the lakes and sea, and became the prey of other fish. You will remember that I stated that this would not tell till 1850, for I was convinced, and am now a greater dogmatist in my own opinion than ever, that we would take very little salmon under two and a half years old. For instance, the fry spawned in November 1847 remained in fresh water till May 1850. They remain at sea three or four months before they return to the mouths of the rivers they had forsaken when fry, and then weigh from six to seven and eight pounds. You will see that this would be exactly allowing the fish spawned in December 1847 to be killed in June, July, and August 1850. I said in my letter of 4th March 1848 that the decline of our salmon-fisheries began with the change of our winter seasons from frost and snow to continual rains, causing high floods, and these floods happening invariably in the months of November and December when the fish are spawning. In December 1847,

during the spawning season, stones above twelve tons weight were carried from the top of the spawning fords above fifty yards down the river by the strength of the current. Where then must the small pea of a salmon, dropped in such a current, have gone, even if it had reached the bottom of the pit where the mother fish intended to deposit it? When our salmon-fisheries were productive, the month of December was what we call a hard month, freezing all through. It is a fact well known to all experienced in the nature of salmon, that in the month of December the greater bulk of the fish spawn, and if freezing then, the fish will come into the fords at night and make the ruts in water not above six inches deep. Here the mother fish begins to drop the spawn, and gets them all deposited, as there is no current to carry them away. One salmon will get more pea deposited in low water than sixty in high floods. In 1847, during the spawning season, baskets full of the spawn could be gathered along the shores at Bundurra, where the preceding tide had left them in the sea-weed. Now, as I have ventured to predict for 1850, I will again venture to predict for 1851 and 1852. The spawning season of 1848 was passable. There were some high floods, but not many that I could call destructive. In 1851 there will be a reasonable take, leaving proprietors and lessors of fisheries fully satisfied that the fisheries have all much improved. 1852 will convince every one that the salmon was not devoured by the renowned sea-serpent."—*Report*, 1851, p. 115.

The origin of this deficiency in 1850 has led to some discussion; and those who maintain that it may be traced to the unfavourable conditions of the spawning season of 1847, of course do so in accordance with Mr Shaw's view, which is, that the ova of that year would produce the grilse of 1850. "That the deficiency in the salmon-fisheries of last year," say the commissioners in 1851, "was mainly produced by natural causes in the spawning season of 1847, is admitted by most persons to whose opinion weight can be attached, and is in some degree confirmed by the improvement in the fishery of the present year referred to in the report of the inspecting commissioners." It is wisely added elsewhere, that if the means and times of fishing be strictly limited to those fixed by law—if suitable passes be made for the migration of fish, and the Sunday or weekly close time be enforced on all coast fisheries, as well as in the estuaries and inland waters—and finally, if the capture, possession, or sale of fish, during close-time, be effectually prevented by the authorities, no doubt need be entertained that these fisheries will obtain a great development.

While discussing the Scotch salmon-fisheries we referred to the subject of drainage disparagingly, as if that agricultural process were often of piscatorial disadvantage. It seems to be otherwise in Ireland, where the system of arterial drainage, and the improvement of the navigation, have been of service.

"To some," observes the inspecting commissioner, "it has appeared anomalous that the fisheries should be benefited by works of drainage, but the experience already obtained fully justifies the anticipations which were formed on this subject. In cases where works have been executed at the mouths or tidal parts of rivers, the deepening and confining of the channels through extensive flats to the seas, and the extension of the tidal influences on brackish water inland, have afforded facilities for the salmon and white trout to enter the rivers; whilst the formation of improved migration passes over obstructions, and the regularly deep channels have facilitated the access of the fish to the upper waters and breeding grounds. The floods, too, in rivers that have been thus opened are much more frequent, though small in amount, than in an undrained country; and where, as in Ireland, the river-courses have but very little fall, and there exist numerous lakes and deep reaches of the river at the back of mill and navigation weirs, the migration of the fish is not only facilitated but promoted, whilst the increased discharge of water into the sea conduces to the capture of the fish by leading them to the rivers. These results have been proved practically in the lower Bann at Coleraine, where the fishery has been importantly increased, at the Fane near Dundalk, the Glyde and Dee, county Louth, and the Balleyteige district, county of Wexford, where salmon and trout were almost unknown before the execution of the works, and where, in addition, large quantities of herrings and other fish have for the last two years been taken within the bar or mouth of the estuary. But in the cavernous limestone districts of the counties of Galway and Mayo still more interesting experience has been obtained. In these districts where very large portions of the waters were discharged by cavernous passages, and through interstices in the strata too small to admit the passage of fish, and where in summer no water was discoverable as flowing from very large tracts of country, very important changes have been effected. In the Lough Corrib and Mask district, lakes containing more than 30,000 acres of water, and rivers and their tributaries more than eighty miles in length, have been opened for the first time to the free access of the salmon, by means of long and deep cuts through rocks, which were required for the drainage of the country, and which as they become completed afford constant streams of water even in the summer season. The salmon have already been taken in the upper waters of these districts, and it would be difficult to estimate the benefits which in a few years may naturally be expected to result from this improved means of access and increase of spawning ground to the fisheries of the districts."

The rivers Dee, Glyde, and Fane, in the Drogheda district, are stated by those who fish in them to have been much improved by the drainage operations. The removal of shoals has enabled the fish to ascend, and more fish have been captured both by the net and the rod than for many preceding years, and the salmon have reached a distance in the upper waters before unknown.—*Report*, 1852, p. 240.

The completion of the works under the drainage acts at the fishing weir or *cutts* of Coleraine, by which the original construction has been altered and improved, has afforded to persons fishing in Lough Neagh and the upper waters an increased supply of salmon, which, while it is not more than equitable to the upper proprietors, will ultimately much increase the value of the lower fisheries. The eel fisheries of the Bann are held by an Englishman, and produce a rent of L.1150 per annum. The salmon-fisheries of the Foyle and the Bann were taken in 1851 by a merchant in Londonderry at a rent of L.2400 per annum.

The principal fishery of the Sligo district, in the town of Sligo, was leased in 1851 to some experienced Scotchmen, who worked it with energy, employing during the close season forty water-bailiffs well armed, and who afforded a salutary protection to the breeding fish. The commissioners were informed in the ensuing spring that the capture of large fish returning from the sea (and which otherwise would have been destroyed in the upper waters) had even then repaid the outlay.

The advantage of improving the salmon-fisheries of Ireland is indicated in the following notice regarding the Bangor district. "The supply of fish here has been very good, and the fresh waters, many of which are occupied by anglers who pay for their amusement, have not disappointed the followers of the gentle art, whose visits to the wilds of Erris are of much more importance than may appear to a cursory observer, inasmuch as that several who have been first induced to visit this remote part of the country to seek for amusement, have either themselves become owners of land, or induced others to purchase, and the sale of property has been considerably assisted by this attraction."—*Report*, 1852, p. 241.

Irish salmon-fisheries.

There is no part of Ireland more interesting, in relation to its fisheries, than the Galway district. We there find two great several or exclusive commercial fisheries—one at Ballinahinch, occupied by Mr Robertson, who has been in use to pack and preserve his fish in tin cases, for exportation to foreign countries; and another called the Galway Fishery, which was sometime ago purchased for the sum of L.5000 by Mr Ashworth, an English gentleman of wealth and enterprise. The rivers Costelloe, Gowlaun, Inver, and Spiddal are occupied by noblemen and gentlemen, who spend the greater portion of the summer in the wilds of Connemara, producing even by that temporary residence great benefit to the people employed. The large lakes of Corrib, Mask, and Ballinahinch, are open to the angling tourist, and their being so induces many to dwell for months by the side of those sweet waters. The navigation and drainage operations, under the board of works, tend to develope the natural resources, and consequently increase the commercial and other value of these fisheries, by connecting the Lakes Mask and Corrib, and so enabling the fish to ascend to the former, from which they can command an enlarged field of spawning ground, previously unprofitable. The clearing of rivers tributary to those lakes, and the formation of upward passes wherever natural obstructions are found to occur, will perfect such important works. Much benefit may be anticipated from the exertions of Mr Ashworth and his local agent.

In our observations on the Scotch salmon-fisheries, we alluded to the alleged advantage of economising the modes by which fish are captured. This is a mixed problem in political economy which we shall not here seek to solve. The natural tendency in all things seems to be towards simplification in connection with discovery or improvement in the mechanical arts. The occupation of the copyist and illuminator of MSS. disappeared or diminished on the spread of printing, but probably far more printers are now employed than were ever penmen of any kind in earlier ages. The following is an Irish writer's view of the bad effects of the mechanical improvement or invention in the art of net-fishing, that is, working by means of *fixed* machinery.

"It is not only in enhancing the price of fish to an extravagant amount, and rendering the fisheries utterly insignificant compared with what they might be under other circumstances, that the monopolists inflict the greatest injury on the people at large, but in the mode in which they carry on those fisheries. Were the public right of fishing in these waters allowed to be exercised, every one who could command a rod or a net might go out and fish when and where he liked best, and thus thousands might amuse or employ themselves according to their tastes or necessities; but under the present system things are managed otherwise. In the fishing seasons the salmon go up from the sea towards the fresh-water rivers. Instead of employing a number of men to pursue them in boats, with nets or lines, in their progress along the monopolised coasts, bays, or rivers, the patentees or proprietors fix down weirs at the narrowest points nearest the fresh-water streams, extending generally in bays and rivers from shore to shore, and on the coasts of the sea as far as possible into the tide. These weirs secure all the salmon that attempt to pass them, and at the ebb of the tide three or four men take them out of the nets or chambers, and bring them ashore. Thus a weir and three or four men deprive perhaps ten thousand people of legitimate and profitable employment. Of the actual numbers thus debarred from employment, the reports before us give no return or estimate; nor have we been able, though we have spared no efforts, to obtain any from other sources; but, to enable the reader to form some conjecture on the matter, we shall state the facts which have come under our observation with regard to the only two rivers respecting which we have been fortunate enough to ascertain any particulars of this nature. According to the report of 1836, there is no part of Ireland in which the rights of the public to fish in the sea and tidal rivers seems to be so well understood and generally exercised as in Wexford. Yet the commissioners, who in this instance only condescended to hear any evidence but that of the monopolists, adopting the statements of the fishermen, say—'The present laws appear to be very strict, and passed as if intended to protect the employment of the fishermen from the encroachment of the gentlemen and weir-owners; but it is quite evident that these laws have remained a dead letter for the last century. The gentlemen and managers who should enforce them became weir-owners, and in the receipt of large revenues therefrom, allowed the fishermen, who were thirty years back a comfortable, well-clad, well-housed, people, to dwindle away into wretchedness and poverty,' though the salmon-fishery, if properly and legally managed, would 'give ample and well-paid employment to one thousand five hundred people for six months of the year.'—*Report*, p. 66. The report does not say, but we suppose, that the herring, mackerel, and other fisheries, would employ them during the remaining six months. The Shannon is 214 miles long from its source to its mouth, and navigable throughout all that extent except for a few miles between Limerick and Killaloe, and a few miles more near its source. It passes through several large inland lakes (one 14 miles by 10); is affected by the tide for 64 miles; is 9 miles wide at its mouth; for 40 miles has an average breadth of 3 miles; and for the remaining 24 miles gradually narrows to something less than a quarter of a mile at Limerick. About 2 miles above Limerick the corporation erected a weir across the channel from shore to shore. This weir was so constructed that not a salmon could pass through or over it. Between it and the main sea the corporation would not allow any one to fish, and between it and the source of the Shannon they of course did not allow a salmon to appear; and thus all the fishing in the river was confined to that one spot, and was managed by five men, four to take the fish out of the weir, and the fifth to kill and count them. Had that weir been indicted and abated as a nuisance, and all other illegal weirs and fixtures along the course of the river been removed, and all persons been allowed to exercise their rights of fishing, and in a lawful manner only, there would have been 'ample and well-paid employment' afforded to at least 40,000 persons."—*Dublin Review*, xi., p. 364.

A bill was introduced into the Irish parliament in 1784 for the promotion of the Irish fisheries, and one of its clauses provided that in each weir in the Shannon there should be fixed a sluice or flood-gate, of six feet in width; and that it should be left open from Saturday evening to Monday morning to permit the fish to ascend the river to spawn. This bill was lost, but a few years afterwards another was brought in and passed. It provides that in every weir in every river, and in the deepest part of that river, there should be a passage 21 feet wide, called the "king's gap," left always open. It is said that this statute has been in most cases disregarded by the weir-owners, and the Limerick corporation for a long time set it at defiance, till legal proceedings were taken against them.

Observations on the subject of bag-nets have been made by the Inspecting Commissioners of Fisheries in Ireland:—

"The use of these engines still continues to be a subject of complaint on the part of those whose interests lie inside their sphere of action, and many allegations are made with respect to the injury which they are said to occasion. It is asserted by some that when they intercept the free run of fish in their courses by the shore, seals and porpoises take advantage of the difficulty of escape thus occasioned, and seize them in large quantities during the confusion caused by these impediments; while others maintain, that when

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placed near the entrance of rivers they turn the fish to sea, and prevent their approach to the inner water; and while we are disposed to concur in the latter proposition, to a certain extent, during calm weather, and in clear water more particularly, we are not prepared to pronounce a decided opinion one way or the other upon the correctness of the former. We regret, however, to be obliged to state that the owners of bag-nets in too many instances provoke the hostility of rival parties by neglecting to comply with the law in respect to weekly close season, and some more unreasonable than others have gone the length of remonstrating against the enforcement of this salutary regulation; but in every instance of this nature which has come to our knowledge we have recommended the penalties of the law to be inflicted, and have refused to sanction any relaxation of its provisions with respect to removing the leaders of the nets, and have on many occasions called the attention of the coast-guards to the authority with which they are invested for the prevention of such offences."—*Report*, 1852, p. 239.

Having now, with greater amplitude than we intended, discussed the subject of the salmon-fisheries in their natural, legal, and commercial bearings, we shall proceed to the sea-fisheries, properly so called, and may as well commence with a notice of those of Ireland, so as to finish what we have to say of the aquatic resources of that portion of the kingdom.

If the sea-fisheries of Ireland are defective in the way of production, this is certainly in no way owing to any deficiency of natural supply, but rather to the industrial spirit of the people not having been successfully and continuously exercised. Some improvements were at one time manifested; but the "famine years," instead of leading to more active exertion, produced the contrary effect. The employment of the people under the labour rate acts, when the average number relieved by daily labour from Oct. 1846 to June 1847 was 356,000 men (the prodigious host amounting at one period to 700,000 persons) however necessary it may have been deemed at the time, had a deleterious effect. Some scarcity of sea-fish is alleged as regards the eastern waters, but this must be principally in those where the poorer fishermen with insufficient gear are known to congregate; for the English trawlers, who fish the deeper waters, and are better appointed, make no complaints. Mr Bartlett acknowledges a steady profit of 30 per cent. upon his outlay. The Nymph Bank, off Waterford, is famous for both the quantity and quality of its white fish. The same observation applies to the fishery of herrings. These fish are said to be less abundant than formerly off the Irish coasts, but they are nevertheless met with by those boats that stand out into deeper water.

When the establishment which had been formed by government in 1819, for the promotion of the Irish fisheries, was dissolved in 1830, it was found that around the coasts of Ireland there were 64,771 fishermen, and 13,119 fishing-boats. In 1836 there were, according to a carefully revised enumeration made by the officers of the coast-guard, only 54,119 fishermen, and 10,761 boats. "This decrease," observe the commissioners, "of 10,652 in the number of persons occupied in supplying fish for the markets of an increasing population occurring so suddenly, while the consumption of all other domestic supplies has been considerably augmented, and in a period during which the markets of Liverpool and Manchester have largely increased the demand on the industry of Irish fishers, is a lamentable fact, too plainly indicative of much local suffering. It appears, however, that at the appointment of the late fishery board, the total fishing population of Ireland amounted to but 36,000, and that during the short course of its activity the numbers increased to nearly the double. Hence it may be inferred that the subsequent falling off must, in part at least, be a result of some previous excess of stimulation; and that the bounties had indeed drawn more persons to this branch of industry than in the then condition of the country were really enabled to support themselves by its exercise without government aid."

It was found, on inquiry, that the fishermen of Ireland generally occupied small portions of land, and often depended for subsistence on that source more than on the sea, their condition being thus mainly determined by the local circumstances of agriculture. Although great distress was too frequently apparent, it was ascertained that the well-equipped and skilful fisherman was able to support his family, independent of the land, on a scale of comfort superior to that of other labourers. It is now distinctly understood, from the experience of the Scotch fisheries, that where there exists a facility of transport to large markets, the sale of fish in a fresh state is safer, and for the most part more profitable, than after they have been cured. Under the existing conditions of some of the remoter coast districts of Ireland this ready market cannot be yet obtained; and when the almost nominal price which a poor though hard-working fisherman sometimes obtains for the produce of his night's labour is considered, his depression and apparent indolence can scarcely be wondered at. The inspecting commissioners inform us that "fine haddocks are now (April 1849) offered at Belmullet for 6d. per dozen." And Mr Wade, a person of experience, who superintends a fishing establishment in Galway, states (in May 1855) that a crew of four men, after having taken forty large turbot in a single shot of their lines, will sometimes have to row them to market 16 miles through a heavy sea, and sell the whole lot for 25s. Yet, that the general quantity of fish, whether fresh or cured, obtained from Irish fishermen is insufficient to meet the demands of the country, is obvious from the quantity of salt herrings imported from Scotland. Wick herrings are found on sale in the great majority of Irish towns, and even at places near the coast, "almost beside the living shoals." As to other kinds of salted fish, such as the dried kinds, the evidence from Galway shows that the Irish fish are cured in a coarse and careless way, and so cannot yet compete with the Scotch or English in the foreign markets. The great success which has attended the establishment of certain stations by the British Fishery Society, such as that of Pultney-town at Wick, indicates the nature of some remedial measure. When steam navigation or a railway is at hand, fresh fish at remunerating prices may be sent a long way to market; but even irrespective of these facilities, a great deal may be done as between an active and adventurous population on the one hand, and a few liberal curers on the other. According to Mr Loch, the great danger of the British Fishery Society arose from a tendency to over-building, while almost all that is essentially necessary to place the curer or fish merchant in a position for active operations, is a convenient and commodious station for his work, and a weather-tight shed for his salt and barrels. The establishment of curing stations in favourable positions in the N.W. of Ireland has been therefore recommended as likely to lead to advantageous results, though, considering the constitutional difference in the character of the people, the commissioners are cautious in anticipating any immediate sequence of those effects which have attended the labours of the British Fishery Society in Scotland. They are favourable to the granting of loans to fishermen in aid of building and repairing boats, and furnishing nets and other gear, a species of benevolence which must be exercised with caution. Where the distress to be relieved arises from disasters at sea, unavoidable sickness, or temporary depression in trade, its relief may be safe, but such relief must not be suffered to draw additional hands into an occupation already sufficiently

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supplied. In Scotland the grants for the repair of boats and aid to fishermen have been recently withdrawn, and the money added to the sums applied to the erection of piers and the improvement of harbours. In the last-named country the curing of fish is kept as a distinct trade from that of their capture, and the necessary advances of money are made to the boatmen by the curers. The Irish commissioners, probably feeling that more was expected from them than was reasonable, have thought it their duty to declare that the result of their most anxious inquiries has been a full persuasion that no means can be proposed for obtaining, by any summary process, so desirable an event as a sudden amelioration of the Irish fisheries. "The progress of a gradual improvement may indeed be assisted and hastened by certain measures, in which the government might beneficially co-operate; but a real and permanent prosperity can only be effected by the hearty endeavours of individuals and bodies locally interested, who, from good motives or trading enterprise, may seize favourable opportunities and apply means for the purpose."

It is obvious from the form of Ireland, her deeply indented creeks and spacious bays, that that great island presents an extraordinary range of coast compared with her actual area. She is therefore surrounded by a proportionally greater and more easily accessible supply of food. The denseness, notwithstanding the recent exodus, of her population, her improved commercial facilities, increasing command of markets, and stronger infusion of the Saxon blood, would seem to hold out a fair prospect of a remunerating trade. From what is known of her natural resources, it might have been imagined that Ireland would not only furnish an ample supply of fish for home consumption, but such a superabundance as would meet and satisfy a foreign demand. But the actual fact is the reverse of this—the quantity captured around her coasts falling far short of the requirements even of her own ill-fed inhabitants. "And during the height of the late terrible famine, when it might have been thought that a people curtailed in the fruits of the land would have availed themselves of those afforded by the sea, one of those anomalous contrasts so frequently occurring in the history of Ireland was presented,—the implements for capture were powerless in the hands of the poor,—the food itself rotted in masses for want of the means to preserve it, and the country obtained its chief supply of an article, the use of which is enjoined by the prevalent creed, from the industry of another people." Hore's *Inquiry*, p. 123. It certainly became the duty of our rulers (and one which was munificently responded to) to enlarge the means of life to a nation undoubtedly afflicted, from whatever cause, by "a desolation wider than any recorded in history, or shadowed forth by tradition." *Report of Committee on Poor Laws* (Ireland). 1849, p. 301.

It was observed that no branch of the industrial resources of Ireland suffered more severely, in the first instance, from the deep distress of the years 1846–7, than the fisheries,—both those of inland waters and the deep sea. It is recorded by the Irish commissioners of public works, that in the autumn of 1846, when the impending famine was certain in all its horrors, and when deaths from starvation had already occurred, supplies of fish, the most abundant which had been known for years, existed on many parts of the coast, and that on portions of the southern and western shores, large quantities of fish were allowed to rot, or were even scattered as "dung upon the earth." This extraordinary state of things is supposed to have resulted partly from a prejudice against the use of fish as a dietary, without potatoes, partly from the utter prostration and distress which the want of food produced (and which compelled the coast population to dispose of their boats, tackle, and all other gear and implements of future earnings, that they might maintain existence), but mainly from the fact, that the fisheries of Ireland, however valuable and important, are not settled or assured on the solid basis of an established trade, nor followed or maintained as a real commercial undertaking for the profit which they would directly yield. Whilst the sea-fisheries were thus injuriously affected by the withdrawal of boats and tackle, left to rot upon the shore, or in pawn-offices, or by the fishermen themselves resorting to the more sure and immediate means presented by the public works, and to soup-kitchens for the bare support of life,—the inland fisheries were materially injured by the increased infringement of the laws passed for their protection and improvement. The poor and suffering people thus appear to have left undone the fishing work to which they ought to have attended, and to have attended to that with which they had no right to intermeddle. "The fact of great numbers of persons dying from want of food (or such profitable employment as would enable them to buy it) along the shores of a sea abounding in fish, and which was calculated to afford remunerative employment in its production, has established beyond all controversy the necessity for permanently developing and relying upon the fisheries in this country as a source of industry and trade, and consequently of food." Sixteenth *Annual Report* of the Commissioners of Public Works.

This total derangement in the social condition of the great mass of the coast population, occasioned by the famine of 1846, rendered it impossible, through the existing registry of boats, to arrive at any calculation even approximating to accuracy regarding the number of men or vessels engaged in the fisheries. Boats lay upon the beaches unemployed and abandoned, not immediately ceasing to exist, but by degrees mouldering to decay, while ownership in many cases was denied, lest this test being applied, might debar the parties concerned from receiving gratuitous relief. The following abstract exhibits the number of vessels, men, and boys upon the register in 1845 before the famine, and the number afterwards ascertained approximately for 1849:—

	Before the famine. 1845.	Since the famine. 1849.	Decrease.
Number of vessels and boats of all classes	19,883	15,247	4,636
Number of men and boys employed	93,073	68,380	24,693

In relation to the preceding, the inspecting commissioners state that they have reason to fear the decrease is underrated. It has since been ascertained that it is greatly so, and that the falling off both in boats and men is much larger than above stated.

The establishment of the government curing stations at Inniscoe, Kyllebegs, Belmullet, Roundstone, Valentia, Castletown, and Baltimore, has been of as much benefit as could, under the circumstances, have been anticipated, and although the commercial winding-up of such undertakings may not exhibit a profitable pecuniary result, yet in an educational point of view, and as examples of an ameliorated system, and a higher standard, much may have been gained. The actual extent of business transacted is, in such cases, of less consequence than the production and exhibition of an improved article, and an opportunity to those who desire training to acquire a better and more thrifty mode of management.[1] Fish being an article that pays no rent,—a

[1] The experiment was tried by making a loan of L.5000 from the Reproductive Loan Society, and considering the nature of the country and its people, that seven stations were formed, buildings, smoking-houses, and others, required for the trade erected, agents, fish-curers, and rents paid, salt, tackle, and other articles imported, and numerous people employed at full wages, and a sum of L.900 returned in a season or two to the Lords of the Treasury, surely a beneficial purpose was obtained.

Several adverse circumstances attended these humane endeavours. The people at Inniscoe were so weak and depressed as to be almost

free gift as it were of nature to its captor,—it might be thought that the occupation of the fisherman would be equal to itself, and require no artificial fostering from without. Yet many nations have made powerful efforts to create or increase their fisheries, and some of them in vain. Sir Charles Morgan assumes that the solution of this seeming paradox lies in the perishable nature of the commodity, and the consequent disproportion between the cost of taking, and that of preserving and conveying it to the distant market. To transport fish in a fresh condition so rapidly enhances its price, that at a small distance from the sea it becomes an article of luxury, and its market is restricted accordingly. Only inferior kinds can be offered for sale at such prices as permit their being used extensively as articles of ordinary food, and these kinds are so low in their nutritive qualities, and so much less tempting to the palate, than what is commonly called animal food, that people who can afford to purchase butcher meat will not consume much fish. Except during occasional large supplies of fresh mackerel and herrings, the artisans of London but rarely purchase fresh fish, and the cured or salted sorts they seem almost entirely to decline. We believe, however, that the abundant supplies of fresh fish, at a diminished price, which are now, by means of railways, poured daily into the great commercial cities of the south, have increased the inclination towards that pleasant and salubrious food.

"To obtain," says Sir Charles Morgan, "an extensive sale for this article, it is for the most part necessary that it should be subjected to the processes of curing, and rendered capable of conveyance to far-distant markets. But the curing of fish, while it implies a considerable degree of art and some outlay of capital, so far decreases the estimation of the commodity in consumption, that salt fish usually finds a still less ready market than fresh, and in thriving communities it is consumed only by the poorest population, and at times when better articles of diet are scarce and inaccessible. The general use of even the best kinds is very much confined to Catholic countries, and depends rather on a dogma of religion than on a principle of political economy.

"Fish, therefore, must be an object of commerce very readily liable to over-production, and sudden fluctuations in the quantity taken greatly increase the difficulty of maintaining a proper ratio between demand and supply. The fish market is constantly varying between extreme points of glut and scarcity; and the necessary consequence must be a low average profit to those engaged in its capture.

"The fisheries, as an object of national importance, depend altogether on a demand for the salted article, and that too in some more extensive market than the immediate neighbourhood of the fisheries ordinarily affords. Before such a market is found and rendered accessible, it is to no purpose that fish abound. They exist in the sea, as good land lies in the back settlements of America. Both are susceptible of supplying the wants of man; but both are useless through their distance from a centre of distribution. Again, the most productive fishing grounds of the British Islands happen to lie principally off remote and ill-inhabited coasts, and before they can become extensively available to the native population, capital and industry must seek them out, and bring to the spot all the materials for curing and for fishing on a large scale. But in a climate tolerably genial, such a mode of investing capital would hardly be adopted, until the demands of agriculture and manufacture were tolerably satisfied.

"Accordingly, it was the Dutch who, having little land to cultivate, and being dependent almost exclusively on commerce for subsistence, were the first to render the fisheries a staple of national industry; and they are still the only nation who have very largely depended on that species of wealth for the source of their prosperity. For England, from its earliest commercial existence, capital has found ample sources of investment without embarking largely in the fisheries. Although its waters abound in fish, the trade for ages was very nearly confined to the supply of the local markets; and it was not until the time of the Stuarts that the fisheries excited public attention; when, owing to the political jealousies then commencing between England and Holland, the desire was formed of depriving the Dutch of their herring trade, and of thus crippling her warlike resources.

"In this anxiety to injure an enemy, the nation did not advert to the different situations of the two countries; but rushing at once into a cumbrous and expensive scheme for becoming *impromptu* fishermen, they entered blindfold upon a series of experiments, from which even now they are not totally disengaged. The eagerness of the nation to jump to the desired conclusion would not brook the naturally slow development of the trade, but strove by monopolies and privileges, by bounties, &c., to force it into a precocious maturity. The result was (as might have been foreseen) reiterated failure; and it was not till the war of the French revolution had utterly annihilated the Dutch commerce, that a real opening was made for the profitable investment of British capital in this branch of industry. To these causes of failure, which circumscribed the growth of the British fisheries, others peculiar to Ireland may be added. Besides the necessity imposed on the latter country of following in the career of the former, two circumstances may have been active in drawing the attention of Ireland to the resources of its waters. 1st. The neglected state of the manufactures, and consequent want of employment; and, 2ndly, the periodical recurrence of local famines. The latter, more especially, could not fail to excite the attention of the public by the dreary contrast it presented between starvation on shore, and an abundant supply of food existing in the neighbouring sea; a supply which wanted only to be taken to become available to the wretched peasantry. Accordingly, the money raised by charitable subscriptions has more than once been spent in equipping the coast population to become fishers; and legislative efforts have been made to attain the same end, in a more permanent way."

The following were the instructions issued to the government agent at each of the established curing stations already named.[1] 1. To afford employment and fair remuneration to the fishermen, by purchasing the fish which they may take, thus ensuring to them, as far as possible, a steady daily market. 2. By a regular market to promote an increased capture of fish, and thus provide an additional quantity of cheap food for the country. 3. To render that food valuable and available to the fullest extent, by adopting such modes of cure as may be required

incapable of exertion; and as soon as the potato planting commenced, the fishermen all abandoned the fishing at the very season when their operations would have been followed by the greatest success.

An unfortunate circumstance happened at Belmullet after the opening of that station, when the fishermen had been for some time delivering large quantities of fish. A body of them residing at a place called Tip plundered a vessel laden with flour,—they were arrested in the act by the coast guards, and thirteen curraghs, with their crews of four men each, were brought into Belmullet. The men were confined in prison for several months, and the curraghs, of course, detained, "which was necessarily a great impediment to the success of the station."!

[1] That a set of cooper's tools could not be found in Ireland suitable to making the vessels required in fish-curing is an evidence of the backward state in which the fisheries remained, considered commercially. A few skilled coopers, with the necessary implements, have been sent from Scotland.

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to preserve it; and such also as will suit the demands for its use either near the coasts, or in markets of the interior.

There was reason to expect, according to the commissioners' report for 1845, that the construction of railways in Ireland would impart new life and vigour to the fisheries, especially those on the western coast, where, although the choicest description of fish are found in great abundance, yet the fishermen are indifferent if not opposed, to the adoption of improved modes of capture, chiefly from want of sufficient and remunerative markets for their disposal. "From some parts of the south of Ireland an export to the English markets of superior kinds of 'flat fish,' packed in ice, has already commenced; and from the whole of the north, east, south, and south-west coast, very large quantities of salmon are shipped, having previously afforded extensive employment to great numbers of persons engaged in their capture, preparation, carriage, procuring of ice, and packing, &c. The progress of improvement in the fisheries of Ireland is doubtless materially checked by want of small piers and harbours on the coast; and we are of opinion that every reasonable encouragement and assistance should continue to be afforded, with a view to remedy this palpable evil, in conjunction with an improved organisation of system in the collection of local funds applicable to the same purpose."

Some have advocated the supply of suitable boats, rigging, &c., by means of grants or loans, through the instrumentality of government, seeing that for a great extent round the north-west coast of Ireland, very few first-class fishing-boats, suitable for deep-sea fishing, are to be found. In one district (Report for 1845) containing 52 miles of coast, there was only one such boat registered, while, in another of 174 miles of extent, there was not a single sea-going boat. The most effectual remedies, and those now advocated, and successfully practised in Scotland, are the erection of additional and more commodious piers and harbours, for the encouragement and protection of men and boats, the opening of markets for the disposal of produce, and an increase in the means of communication.

In the commissioners' twentieth annual report (of date August 1852), we are informed that the opening of the railway from Dublin to Galway has given great stimulus to the fresh fish market there, and large supplies of sea-fish and lobsters have been sent to Dublin and the English markets by that route. They look forward to much greater results so soon as certain local prejudices regarding trawling, and the improved modes of capture, gradually yield to the influence of a regular daily market, and remunerating prices. The branch from the Dublin and Cork railway to Kilkenny, and the completion of the line between Waterford and Limerick, Waterford and Kilkenny, with the increasing steam navigation from these ports, have operated in giving a new and increased value to the fisheries of the south and west coasts. It is regretted that the county of Sligo, and the greater portion of Mayo and Donegal, have no immediate prospect of such advantages, although they possess some of the finest fishing banks off their coasts, but require railway communication as the primary means of developing their industrial resources, by placing them more upon an equality with the rest of the kingdom. The gradual junction and completion of the northern Irish railways, and the daily steam communication from the ports to England and Scotland, have already afforded to those quarters the advantages referred to.

The deep-sea fishing of Ireland is carried on chiefly by means of long lines called spilliards, better known as spillets on the western coast. The species taken by that mode are cod, haddock, ling, hake, conger, and dog-fish. Very large haddocks, said to weigh from 15 pounds and upwards, are caught off Clew Bay, on the Innishay banks, but they are in bad condition by the time they reach the markets of Newport and Westport. The ling and cod are also very fine. The spilliard line has generally a length of 210 or 220 fathoms, with hooks fastened to it by snowding lines of nearly two fathoms in length, at a fathom's distance between each snowding. There are thus 200 baited hooks on each spilliard, one spilliard is a man's share, and every boat carries five spilliards, or 1000 hooks. These, after being baited, are arranged in a basket in circular rows, and the line is set by the boat being rowed over the fishing ground, the hooks descending over the side, and dropping into the sea without entanglement, as the line veers out. If the fish are biting freely, the first hooks are lifted immediately after the last are laid, but it is the more frequent practice to let them lie from six to twelve hours in the water. The bait is usually small pieces of fish of about an inch square, and half an inch in thickness. The conger eel is the most successful kind in use upon the western coasts. The mussel is the best bait for haddocks, lug-worms (much in favour with flat-fish), and the inhabitant of the scollop shell, are also had recourse to. In many places there is a scarcity of bait, and consequently a difficulty in obtaining it,—an inconvenience also experienced on the Scottish coasts. These spilliard lines are partially supported by buoys, placed at long intervals, made of dog skins filled with air, and called watchmen by the natives. Mr Brabazon informs us, as an example of what may be achieved in this way, that in the early part of 1847 three boats left Port Rush, and went round to the western coast to try the long line fishing. They returned, after an absence of seven weeks, with a cargo of thirty-six long hundred (of six score) of ling (that is 3600 fish), which they sold for 8d. a piece, independent of a supply of cod, hake, conger, and six barrels of oil to each boat, taken from the cleanings. These people green-salt their own fish. Four men split and gut them, two men wash them in a trough full of pickle, and as soon as they are clean, two men carry them up the beach, and lay them out on rocky or stony places, free from sand. They are afterwards packed up in large square piles upon the beach, being covered with a tarpauling in wet weather, and also at night to keep off the dew as well as rain. The Rush fishermen have eighteen score of hooks to each man's share of line, and they have a buoy at the end of every share. The lines are shot in succession from the boat, according to lots previously drawn from a hat, if they have one. They are shot across the tide, which keeps them clear, for when dropped with the tide the lines are apt to bunch up, and so get foul. They dare not shoot them in stormy weather, as the friction on the buoy line produced by the rolling at the surface would cut them across, and the rubbing against the bottom is also injurious. This fishing is usually practised over rough and rocky ground, or in water too deep for trawling. It occasions great fatigue to the men, who have to go to and from the scene of operations, in small row-boats, every day. To remedy this inconvenience various plans have been suggested, especially the establishment of fishing companies, with large vessels, well supplied, and capable of standing out at sea till a full cargo is obtained.

"A company," says Mr Brabazon, "undertaking the Irish fisheries for profit, at the same time that they gave remunerative wages, and afforded the fishermen of the coast a certain medium price for their fish, whether there was a glut of fish in the market or a scarcity, would be the best way of improving the condition of the people along the west coast, and certainly lessen the effects of famine with which they are so often visited, by the failure of their crops. The company should establish stations along the coast; say they began with three, one at Kyllebegs, one at Newport Pratt, and one at the Shannon mouth, it would be found that when vessels could procure a cargo of cured fish without delay at

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the company's stores, it would create an extensive trade with the west of Ireland in fish, corn, coals, and salt. Each station should have a store, curing house, and ice-house attached to it. From the store at Ballyshannon, I would send the fresh fish packed in ice, and also cured fish by water carriage through the Enniskillen lakes, and by the Ulster Canal on to Belfast, supplying all the intermediate towns and interior of the country, giving a great deal of employment to the owners of carrier boats at so much per ton freight, and have it sold by agents at different localities through the interior, who would be paid by a percentage on the sales. Upon the same principle, the fish from the station at the Shannon mouth could be sent up the Shannon per steamer, and on to Dublin, taking advantage of the cheap water carriage afforded by the canal. The company could either have their own boats for carriage, or give that employment to the carrier boats already established on these lines.

"The chief expense to the company would be a fleet of three or more large wherries or schooners of about 150 tons burthen at each station, and a tender of 50 tons. They could attend all the fisheries, herrings, long-lines, sun-fishing, and trawling, at their different seasons. I would prefer wherries to cutters, as they have not the great weight of masts that cutters have, the weight being divided, which would make them work much easier in the heavy rolling seas of the Atlantic, nor have they the great weight of boom of a cutter, which takes up a good deal of room, and requires many hands to work in stormy weather; they are also much easier made snug in a short time in a heavy burst of bad weather, or white squalls, so common on the west coast of Ireland; also from their having a long line of low canvas, when close reefed they can beat into shore in any gale, when a cutter, from her narrow taut trisail, would make a bad hand of it. One fact in favour of the wherry rig is, that there is a wherry in Howth (the Bull) of 40 tons burthen, which on several occasions carried the mail-bags across to Holyhead in the days of the sailing packets, which were fine cutters of 70 tons, but which could not put to sea in such weather. They have a great advantage as trawlers in the act of jibing, which they often go through while shooting their trawl. The expense of each of these vessels would be about L.1000, fully found with trawling gear, long lines and hooks, herring nets, harpoons and lines, and two good whale boats for each vessel, so that they could attend each fishery in its season. These vessels should be manned by a crew consisting of a skipper, mate, or store-keeper, three men and a boy, who should have charge of the vessel and never leave her. I would take crews of the coast fishermen for the whale boats, that is, two crews for each boat out to the fishing ground, and maintain them on board until the vessel had her cargo of fish caught, then return to the station, discharge her cargo into the store, take in fresh provisions and water, and go to sea again. These vessels could run out to the fishing ground with the crews of the whale boats on board, a crew could then man each of the boats, and shoot their lines from them; while the two spare crews on board could also shoot their lines over the vessel's side, when the crews of the whale boats lifted their lines and came on board to take off the fish, and rebait the first lines shot, the spare crews could man the boats and lift the lines that had been shot from the vessel. Thus each boat's crew could make three or four shots of as many sets of spilliard lines as belonged to each crew in the day, as they would not be fatigued with rowing or sailing fifteen or twenty miles to the fishing ground, but leave the vessel's side fresh after their meals. During the time they were fishing, the vessel could beat up to windward and shoot her trawl, which would keep her under such easy way that the boats could make her at any time. If there was a great take of fish, and fine weather, these vessels could tow out four or five of the shore boats with their crews also, sell them what provisions they might require, and buy their fish at so much per cwt., and give it a partial salting on board,—what the North Sea fishermen term green-salting, that is, in case of their being delayed at sea. Then on Saturday evening run into the station, land their cargo, replenish the ship's stores, and run out again to their fishing ground on Monday morning. It is only by fishing with large vessels of this class that the great difficulties presented by the storms of the Atlantic, and the mountain tempests of the Irish coast, can be successfully contended with."[1]

This scheme of a commercial fishing company for the advantageous development, in favour of all concerned, of the marine resources of Ireland, is advocated and explained in a more recent work.[2] Galway is recommended for the headquarters of the company, as combining all the advantages requisite for success. It is situate at the head of a magnificent fishing bay, thirty miles long and seven miles broad, in which almost every sort of fishing may be carried on throughout the year in its respective season. It is likewise in the centre of a district of coast abounding with fish and bait of every kind, with good harbours, and a fishing population of 7297 men, 497 boys, with 1818 boats, while there are extensive salmon and white trout rivers, from which these fish may be obtained on advantageous terms. There is a considerable local demand for both fresh and cured fish, especially for the somewhat coarser kind, which do not so surely pay the expense of distant carriage; there are capacious docks, with storeage and curing houses to any extent desired, at a moderate rent, with cheap markets for provisions, and a railway station within six hours of Dublin, eighteen of Birmingham, and twenty of London. The craft recommended are, vessels from seventy-five to eighty tons, some of them to be fitted with wells for keeping fish, lobsters, and bait alive; also a smaller class of vessels of from twenty-five to thirty tons for the drift-net fishing, and a class of row-boats, from thirty to thirty-five feet long for the bay herring and mackerel fishing, and for working the seine nets. Lastly, a fore-and-aft schooner well-boat, with an auxiliary screw propeller, to be employed in carrying fish from the vessels on the banks, or the stock purchased at the stations along the coast.[3] She would prove a valuable auxiliary in towing the vessels or drift-net boats to the fishing grounds in light weather, and in the capture of sun-fish, which generally show themselves during calms. Commander Symonds concludes his pamphlet by the following *résumé*, p. 55.

1. That the waters of the west coast of Ireland abound with cod, turbot, soles, lobsters, and other fish of the finest quality. 2. That the want of success which has heretofore attended any development of these fisheries, has arisen from

[1] *The Deep Sea and Coast Fisheries of Ireland, with suggestions for the working of a Fishing Company.* By Wallop Brabazon, Esq. Dublin: 1848.

[2] *Observations on the Fisheries of the West Coast of Ireland, having reference more particularly to the operations of the London and West of Ireland Fishing Company.* By Thomas Edward Symonds, Commander, R.N. London: 1855.

[3] "In the construction of the above vessels it will be necessary to effect such a combination of form and rig as will render their adaptation to different modes of fishing both facile and expeditious. They should unite considerable speed with average stowage and good accommodation for the men, and have the least possible amount of gear and rigging, so as to keep down wear and tear. These advantages may be readily combined in fore-and-aft schooners, similar to those the Americans use in the South Sea seal-fishery, which are splendid sea boats; this rig is admirably adapted to the west coast of Ireland, which, in common with all mountainous coasts, is subject to sudden and heavy squalls when the wind is off shore, the sails and spars being lighter and more easily handled than those of a cutter of half the tonnage."—Symonds, p. 12.

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the inadequacy of the capital and means employed. 3. That there is in London alone a demand for fish exceeding in quantity anything which could be imagined by those who have no practical experience in the matter. 4. That the regular supply of fish to the principal markets in better condition than has hitherto been accomplished, and at a lower price, must necessarily create a more extended demand. 5. That the application of steam in the manner suggested, and which forms one of the main features of the London and West of Ireland Fishery Company, is an element of the highest importance in an undertaking of this kind, and, combined with the favourable arrangements which will be made with railway companies, will save the loss of time which has heretofore occurred, and consequently the enormous loss occasioned between the quantity of fish caught, and the quantity capable of being delivered at the markets in good condition. 6. That the application of a process for converting the coarse fish, and the refuse at the different curing stations, into manure or fish guano, will itself form a valuable source of revenue, by turning to profitable account that which is now thrown away. 7. That the application of capital on the west coast of Ireland, in a national point of view, must be attended with most beneficial effect on the national industry of the country, and the conversion of the waste fish into manure must also be hailed as a boon to the agricultural interests.

The fishermen of the western shores of Ireland, however uninstructed in many things, are said to understand their own vocation well, at least so far as hook-fishing is concerned. What they chiefly want are more regular markets to induce and reward continuous labour. Their boats are, however, too often "ill-found," being very deficient in sails, rigging, and fishing gear. Mr Brabazon mentions, that scarcely one crew in every ten in Clew Bay have fishing tackle, but believes if they were supplied with the requisite materials at a moderate price, they would bring ashore great store of fish. The distress among the fishermen of the east coast, he thinks, is chiefly caused by the spawn upon the fishing banks being destroyed by trawlers, while on the west coast their poverty arises from the want of markets or demand for fish. "The fishermen often see the west coast crammed with fine fish, when they could take tons of them at a haul, or shot, with a deep seine or drift-net, but when caught they would be useless, as they could neither salt nor sell them. I have been told by an inspecting officer of the coast guard, that he has several times seen herrings on the coast of Donegal sold for 10d. per 1000, which would make two barrels of herrings, worth in Dublin L.2, 10s. Different persons, to whom I have talked about the fisheries on the west coast, expressed a doubt that bait could be found in sufficient quantity to carry on an extensive fishery. I have never felt a doubt upon this point, as any fisherman will tell you, that wherever there is a *fish* there is a *bait*, as the fish are the bait in case a less expensive one cannot be obtained; but there is always a mixture of inferior fish fit for bait in the same shoal with prime fish."

The boats which prosecute the herring-fishery off the western coasts of Ireland are very inadequately provided, especially as regards the smallness of their train of nets. Each train is generally composed of from six to ten parts called slings, and a sling is about 25 fathoms in length. The Galway and west coast nets are 6 score of meshes (about 9 feet) deep, while our Scotch nets are at least 15 score, or 22 feet deep. Thus the Irish nets are so narrow, that large shoals of fish can easily pass beneath them, even in a moderate depth of water, where a Scotch net would stop the passage and *mesh* the fish. The Irish nets are generally attached to what is called the back rope, and the buoys have seldom more line attached to them than suffices to secure them to that rope. Thus the upper edge or line of the net is necessarily always at or close upon the surface, as there are no means of lowering it, however deep below the fish may be. But the St Ives men and our Scotch fishers, besides having deeper nets, can let them sink by lengthening the buoy ropes, which are fastened at intervals to the back rope, or that called the spring-back, which runs along the whole length of the train, and is strong and thick from its fastening at the boat to about the centre of the train, and lighter from that centre to the farther end. The buoy ropes are several fathoms in length, so that the nets can be depressed from, or raised towards the surface, according as the shoal of fish is high or low.

That the herring-fishery might be made of great value to Ireland is evident from the fact, that her people frequently import above 100,000 barrels of that fish from Scotland. It is alleged that a great falling off has taken place in the herring-fishery of Ireland for ten or twelve years (prior to 1850). Formerly abundant supplies were frequently obtained upon the west and south coasts, purchasers from Scotland and elsewhere attended, and a trade existed upon a large scale, of great importance to the country. It is not improbable that the fish are still upon the coast, although they may not now embay in the same places as formerly. Changes of this kind have been noted as occurring off the western isles of Scotland, especially about St Roag and other stations on the outer shores of the Long Island, in the bays of which herrings, now rare, once abounded. But there is no doubt, that a fair fishing harvest is still reaped from year to year, by others than the natives, off several portions of the Irish coast. A herring-fishery is uniformly prosecuted off the east coast of Ireland, whither a fleet of between 200 and 300 vessels, chiefly Cornish, annually repairs, and for several weeks is continuously and profitably occupied in the capture of these prized fish, for the supply of the Dublin and Liverpool markets. The commissioners (in their Report for 1851) remark, that the only really important herring-fishery which came under their observation in a concentrated form, was most abundant. "Our *Cornish neighbours*, this year, have visited Howth and Kingstown in increased numbers, and with unusual success. They have had an excellent season, a fair take, and good prices." These results seem all that fishermen can reasonably look for here below.

Many of these fish, after coming into the hands of Scotch or English curers, are shipped to Dublin and other Irish ports, and sold there at from 26s. to 30s. per barrel. It is clear that if cured upon the spot, they might be disposed of at an equal profit to the producer, and at a great reduction to the consumer.

In regard to the natural abundance of Irish fish, we may here quote from a report made in December 1853, by Mr Howard, a gentleman who has been fishing the North Sea and coast of Norway in welled vessels during these last thirty years, for the supply of the London markets with live fish and lobsters.

"Having proceeded all round the southern coast from Cork to Breahaven, and from my own inspection, and from what I heard from persons of all classes, I have no hesitation in saying, both as regards quantity and quality, the banks off the coast and the Irish shores are richer in fish of all descriptions than those of any country I have ever seen. I spent a day and night at Kinsale—the only place in the south of Ireland where the fishings are carried on to any extent. There are, I think, about forty hookers, the largest only thirty tons. These being only half-decked could not with safety, I conceive, live in a heavy sea; and as not one of them has a well, the fish are killed as soon as captured, and daily brought on shore; and I am further convinced from the inspection of all the fishing gear, that not half the quantity are taken that might be, if the hookers were equipped in an efficient manner. I saw the fish on the morning of the 29th, when landing from the vessels; the cod, haddock, and ling, were very prime,—the haddock, I

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am convinced, the finest in the world. I proceeded along the coast to Crookhaven, Bantry, and Breahaven; at every place we found the fact corroborated as to the abundance of fish; but, except a few small boats in Glandore, Baltimore, and Breahaven, there were none to be heard of, as the fishing has nearly ceased from 1847, in consequence of famine, emigration, and no market for the fish, if taken. On returning from Breahaven to Bantry, we came by boat, and literally rowed across that fine bay through a *bank of herrings;* and I feel confident that with nets, such as those used in Scotland, the Isle of Man, or on the Cornish coast, 40,000 barrels might have been taken that night; in fact, the whole coast was swarming with them, and if properly fished, would rival Scotland in her annual take."

The following relates to the produce of the Galway coast. "The Claddagh fishermen have been blessed by Providence with an abundant harvest, in their line, this week. On Wednesday night the boats were actually laden to repletion with herrings. They had scarcely reached the roadstead, going out to lay their nets, when the shoal met them, swimming against the sides of the boats, and under the clear and beautiful moonlight, illuminating the bright waters as though it was a sea of silver on which they floated. Next morning the cargoes were sold, but not at a price equivalent to their value: 17s. per 1000 was the highest figure, and from that down to 14s.

"The herrings were remarkably fine, some of them being nearly of the size of bream or mullet. The quantity of hake, cod, and other fish taken, was unusually large; and if proper sources for the sale of it were available, the fishermen would be well rewarded for the risk and labour they undergo. Very fine hake or cod fish hawked about would be bought for a penny or twopence a-piece."—*Saunder's News Letter*, 6th November 1854.

The western coast of Ireland has, moreover, like Yarmouth, and our own Firth of Forth, the advantage of a regular *winter herring fishery,* which, if assiduously prosecuted, and with the aid of a screw-steamer, in addition to the railways, might be made very profitable, during a season which admits of a lengthened journey, with little diminution of freshness. The fish are of great size, and when in full season fourteen of them are said to weigh a stone. They make their appearance in December, and generally remain for about ten weeks. They may be often purchased, in any quantity, at from 10s. to 15s. per long thousand, while in a great city market they would probably realize in retail from 6s. to 8s. a hundred.

The *cod* and *ling* fishery of Ireland may be prosecuted during ten months of the year, being divisible into the early or in-shore fishing, and the late or distant fishing. From the month of November until the middle of March the cod fish are in prime condition. In May 1853, Captain May of the coast guard at Clifden, county of Mayo, stated that a person of the name of Butler of that place was absent for three days in a small hooker of five tons, with four men, and returned with forty dozen of fine ling. In December 1854, a row-boat, with eight men belonging to Cleggan, in Mayo, took fifty dozen in nine days, besides a quantity of other fish. It has been inferred that if these quantities are not unfrequently taken in a desultory manner by ill-equipped vessels, a much larger capture would reward those who pursued the fishing in a more systematic and efficient manner.

There are great quantities of *turbot* on the west coast of Ireland. They often cut up these fine fish *for bait* for their long lines. Boys will wade into the water with small spillet lines, and with these they will take from fifteen to twenty *chicken*, or young turbot, at a cast. *Haddocks* abound, and if kept alive in welled boats, so as to reach the London market undeteriorated, would fetch a high price. In the west, according to Commander Symonds, they are of great size, and when fresh and in fine order, are even superior to the celebrated Dublin Bay haddocks. The *soles* are said to be equal to those of Torbay, and may be taken in large quantities at Dingle, and many other places, as well as in the deep sea. *Hake* fishing begins in June and ends in November in Galway Bay, and during that time from 500 to 1000 are usually taken in a haul of five or six hours in the trawl-net. *Dory, brill, holibut,* are abundant. Large *mackerel* are driven into Arran (thirty miles off) by the sun-fish in spring, but a smaller kind swarm in Galway Bay in June. *Sprat* fishing is followed chiefly for the sake of the oil, and the fish themselves are bought at a cheap rate by the poor people after the oil has been expressed. The quantity is almost unlimited. From August to Christmas last (1854), they may be said to have existed in a solid mass both within and outside the Galway docks, and on several nights they rose to the surface in such numbers that the people took them up in hampers, which they filled to the brim at a single dip. A person totally unacquainted with trade was induced to expend L.250 in the purchase of sprats, from which *four thousand gallons* of oil were made, worth about two shillings per gallon, or L.400. "After expressing the oil," says Symonds, "nearly 300 tons were sold for food, the proceeds of which covered all expenses." The selling price, in the fresh state, is from six to ten shillings per ton. *Lobsters* are very plentiful along the west and north-west coasts of Ireland. Large welled boats are sent from London and other English ports, and purchase them for from four to six shillings a dozen. *Ten thousand* per week may be obtained at that rate from many stations, and the average wholesale price at Billingsgate is one shilling each, or L.50 per thousand. The returns of the Midland and Great Western Railway of Ireland show that 101 tons 6 cwt. of lobsters were carried from Galway by that line, in addition to those transported by sea to London.

Another occupation, formerly much practised in Scotland, but now almost peculiar to Ireland, is that of sun-fishing. The sun-fish is the *Squalus maximus*, or basking shark. If the weather is bright and warm towards the end of April these gigantic creatures are sure to show themselves, and are visible at a great distance to a practised eye, in consequence of the dorsal fin projecting several feet out of the water, while its owner lies upon the surface basking in the sun. At this period of unwary indolence they are easily approached by a boat, in the bow of which a strong-armed man stands steady with harpoon in hand. The barbed weapon is attached to a line of 200 fathoms coiled up in circles on the fore-sheets, and another man is near with a hatchet ready to cut the line should it chance to get entangled with anything in running out. When the fish is first struck he makes a tremendous rush of a hundred fathoms, or it may be more, descending, as the fishermen allege, to the bottom, where he rubs and rolls himself to get quit of the harpoon. He is generally allowed to take his own way for about an hour before his captors begin to haul upon the line. In doing so they carefully coil up the slack in readiness for another run, just as the salmon-fisher keeps his reel in order, with this difference, that the worst mishap will only graze the skin of the angler's finger, whereas in the case of the *Squalus* a man may be drowned, or lose an arm or leg, by the rapid motion of the rope. Sometimes, when the fish is powerful, as well as sulky, eight or nine hours will elapse before he comes to the surface, having this great advantage over a whale, that he can breathe under water. He is struck again as soon as an opportunity offers, with one or more harpoons, and is finally hauled to the vessel, alongside of which they stretch him fore and aft with a jowl rope around his head, and the bite of a hawser round his tail. His own bite is not to be trusted, and to destroy the enormous power of his caudal extremity, two deep cuts are inflicted with a hatchet on each side the tail. They then cut flesh holes in his body on both sides, through which they reeve strong

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ropes, and by hauling these taut on the side of the fish next the vessel, and slacking away on the opposite one, they contrive to cant him over on his back. They then split him down in front, take out his liver, and allow his huge carcase to go adrift. This fish, which is of great thickness, sometimes measures thirty-six feet in length. There is no blubber between the skin and the flesh as among whales, but the oil from the liver is as fine as spermaceti, and a single fish will yield a couple of tons worth L.50. They are frequent on what is called Sun-fish Bank, about 100 miles west of Clew Bay. The fishermen there reckon it a day's sail out of sight of land. They are also met with in large numbers off Tory Island, and along the north-west coast of Donegal, where the Skerries men have sometimes found them so abundant that they dared not venture out to lift their cod lines in case of accidents to their boats. Though of a sluggish nature they must be harpooned with caution, as a blow of their tails would stave a boat to pieces, or throw the wounded men into the water. The chief defect in the Irish mode of attacking the sun-fish is, that the fishermen are unacquainted with the use of the lance, a deep thrust from which, instead of a second harpoon, when the creature rises, would accelerate its final capture.

We shall now consider the important subject of the sea-fisheries of Scotland. Of these the most valuable is that of herrings. The Caithness herring-fishery is, for the time it continues, the most abundant in Britain, and Wick may be regarded as its most productive centre. Like the salmon-fishing, that for herrings is more or less a lottery. The average of the Wick fishing may be stated at about 100 crans[1] per boat, though some boats may land in all from 300 to 400 crans, while many may have far less than even the first named number. In addition to the improvement in the modes both of capture and cure, three more extrinsic things have tended greatly to the advantage of the fisheries in recent times. 1st (and this chiefly as relates to salmon), the invention of the use of ice; 2d, the introduction of steam-navigation; 3d, the formation of railways. In illustration of the vast advantage of the last, it may be mentioned that between *four and five thousand tons* of fresh herrings are now sometimes sent in a single season of a few weeks from the town of Dunbar alone, into the interior of the country. What a vast benefit to the great commercial and other cities of the south to have so cheap a supply of such salubrious food![2]

We shall not here enter into the natural history of the herring further than to say, that all that is stated by Pennant and others since his time, regarding the migrations of that fish from the northern regions, and its breaking up in vast bodies on both sides of Great Britain and Ireland, is without the slightest foundation in fact. The herring is a native fish which breeds along our shores, and never altogether leaves them, although it becomes invisible for a time, especially after the spawning period, by sinking, for security, into the deeper sea. The truth is, that at one station or other we may be said to carry on the herring-fishing all the year round. It commences in May off the eastern side of the Lewis or Long Island, and continues into mid-summer. It then spreads along both the western and eastern shores of Scotland, attaining its maximum off the Caithness coast in August. It continues in Loch Fyne and other western sea-lochs almost into the winter season. It commences in autumn off the Yarmouth district, and continues during a portion of the winter. It recommences in December in the Firth of Forth (unexhausted by the summer slaughter), and is carried on as a winter fishery. Finally, it prevails at Ballintrae, and other places off the Ayrshire coast, in spring, by which time, however, the fish are spawning, and in bad condition. We have then only a few blank weeks from the end of March to the middle of May, when herrings begin to show themselves again, as we have said, off the Lewis, at first in rather poor condition, but improving rapidly there and elsewhere as the season advances. The young are found, and too often captured, in our firths and bays of the size of sprats, a sufficient proof, had we no other, that the notion of the parent fish retiring to breed among the arctic regions is a fable.

There is no article of diet more palatable and salubrious than fresh herrings in first-rate condition. In their natural state these fish may be divided into three classes, viz., maties, full fish, and spent fish. Maties are those in which the roes and milts are distinctly but not largely developed, and this is the state in which they are in the highest order as food. Although they do not then exhibit so bulky an appearance as that of the full fish, they are in reality much fatter, for the bulk of the latter is deceptively produced by the great enlargement of the roe and milt; and this does not take place without a corresponding diminution of the body of the fish. The full fish, however, are those which are most sought after in a mercantile point of view, especially for the Irish market, because of their larger size. They are also much more abundant than the others, or at least are captured in much greater quantities, as they are then congregated in larger shoals, and also, being nearer their spawning time, make closer approaches to the shore. The great north-eastern herring-fishery of Scotland is mostly made up of full fish. It commences about the middle of July, and by the beginning of August is often general from the Tyne to Shetland. The earlier Dutch fishery contains more maties, and is carried on at a greater distance from the coast. It is of importance to encourage an early fishing among ourselves, for the sake of somewhat cooler weather, which admits of more careful and deliberate salting. August, which is, however, the chief herring month, is not seldom sultry. We shall now describe first the mode of capture, and then that of cure.

Our principal herring-fishery has, almost from time immemorial, been carried on by *drift-nets*. There is no *close time* as regards these fish, nor any legal regulations, further than that the act 48th Geo. III., cap. 110, sec. 12, declares that the meshes of these nets must not be less than one inch from knot to knot, while a more recent act (14th and 15th Vict., cap. 26, sect. 6) makes the use of the *trawl-net* in the capture of herrings illegal.

A train of herring drift-nets consists of several lengths

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1 A cran contains 45 gallons of ungutted herrings. It is the measure by which the captors deliver their fish to the curers, or other purchasers. A barrel contains 37½ gallons of gutted herrings, and is the measure in which the salted fish are sent to market. It ought to be capable of containing 32 gallons English wine measure.

2 The number of boats fishing from, or visiting Dunbar (though belonging to other stations) in 1853, was about 350. The quantity of herrings landed at Dunbar in 1853 was 43,000 crans. The value of herrings landed at Dunbar that season was L.34,500. The value of boats and gear employed was L.43,000.

"The above," observes Mr Sutherland, the fishery officer at Eyemouth, from whom we have the information, "are for both harbours (of Dunbar), and but for the existence of Victoria Harbour (that so largely aided by the board of fisheries), probably not more than one-third of the business could be carried on satisfactorily, particularly now that there is such exertion used to get fish put quickly into packages for despatch to market, every available space on the quays and about the harbours being taken up in this way."—MS., 29th Sept. 1854.

It is evident that the combination of a railway station, with increased harbour accommodation, has rendered Dunbar a highly eligible point for the inland transit of fresh herrings. Mr Sutherland adds that the price is generally higher there than at any other station on the east coast, and that this is an additional inducement for fishermen to frequent the port. We may here note that Dunbar is included under the *Eyemouth* district in the board of fishery returns.

of nets united together in a line, and kept suspended in the water by means of buoys floating on the top. The different lengths of the nets so united are, in fishermen's language, measured by barrels, each length being about the quantity of net a barrel would hold. A barrel of nets is generally 90 yards in length. The depth of the net is from 20 to 24 feet, and when new, it costs from L.4 to L.5. A whole train consists, according to the wealth of the fishermen, of from 7 to 25 barrels of nets. It measures from 600 to 2000 yards in length, and its value is from L.25 to above L.100. A strong rope runs along the back of the train, which is called the "back rope," and to this the buoys are attached by short ropes for floating the net in the water. In the narrow waters of Loch Fyne, about Tarbert and its neighbourhood, where the Loch is some four miles wide, the average length of train runs from 8 to 15 barrels, or from 650 to 1350 yards. Further down, between Arran and the Argyllshire coast, in the Sound of Kilbrennan and towards Campbeltown, the longer trains of 1500 or 2000 yards are used, and in the same way on all parts of the coasts, long trains are preferred wherever there is sufficient space for them.[1]

Owing to the great bulk of a train of nets, a boat of large size is required, and accordingly, the regular full-sized drift-net boat is one of a superior description, the best and largest class costing from L.60 to L.100, with a crew of from four to six men, though an intermediate kind, costing less, with a single lug sail, and from two to three men, is sometimes used. In Loch Fyne and about the Clyde, the greater part of the drift-net boats are sloop-rigged, with three sails, requiring some degree of management. These boats often make voyages of considerable length, such as to the Isle of Man and the Island of Lewis, whereby the crews become acquainted with the use of the compass, are inured to the sea, and gain the rudiments of seamanship—making this class of boat a valuable nursery for seamen.

The nets having been put on board, the boats sail to those parts of the loch, or adjoining sound, or sea, where it is expected fish will be found. As almost all the fishermen take the same signs as a guide for finding fish, the boats thus gather together in fleets in particular spots, and so long as fish are found there, or are hoped for, the boats do not remove, but continue fishing in the same place.

The process of setting a drift-net is as follows: as soon as a boat reaches the fishing ground the first net of the train is put out over the stern, and the boat is gently sailed or rowed, the men in the stern carefully tending the nets as they pass out, till the whole train is in the water. The boat is then made fast to the train by a rope of about 20 fathoms, called the "swing rope," and both boat and train drift together with the wind or tide. The further end of the train, according to the situation and the nature of the ground, is either left floating, or fixed by a rope called the "tailing rope," to an anchor or stone, and sometimes is made fast to the shore. Putting the net out of the boat is technically called "shooting the net;" and drift-net boats, to give room to each other, and prevent fouling and collisions from unequal drifting, usually shoot so as to allow a clear space of about 60 yards between the train of each boat after the whole have shot. The nets are always shot at or soon after sunset, and the fishing goes on through the night.

It requires some time to shoot a train of nets, but it takes still longer, and is a work of more labour, to haul it in. The drift-net boats therefore are particularly loath to shift their ground often, by which so much time and strength are expended. Still, however, to prevent too long lingering on unfavourable ground, an arrangement or privilege is admitted among fishermen of lifting out of the water parts of each other's nets to examine, and see whether fish are in them or not. This is technically called "preeing," and when no fish are found, the news spreads, and frequently becomes the signal for the boats to haul in their nets, and move away. This "preeing" is viewed with some jealousy. The immense length of the trains, and the distance of the owners from almost every part except just the last net to which the boat they are lying in is fixed, make them fear plunder or injury of their nets under a false pretence. For the same reason, the moving about of small boats among trains of nets is much disliked and objected to, and drift-net boats seldom or ever take any small boat with them. A small boat, besides being rarely wanted, and therefore rather an incumbrance, is regarded by fishermen as giving most mischievous opportunities for pilfering from nets, and they set their faces against it. The fish are caught by *meshing*, that is, by pushing their heads and gills through the interstices of the net, from which they have no power to withdraw them.

In former years, in Loch Fyne and its neighbourhood, at the early part of the season, it was common for drift-net fishermen to take off from their trains, perhaps two or three barrels of nets, and securing one end to the shore, carry the other end out into the loch, and make it also fast there by an anchor or stake, thus forming a set net. This net was technically called a "trammel net," and was often very successful in taking herrings of large size, and fine quality, the widest meshed nets being generally selected for setting as trammels. But the system of drift-net fishing, as above described, is the one almost universally practised on our eastern coast, and is also the usual one elsewhere.

The net distinguished by the herring fishers of Scotland as the *trawl net*, is improperly so called, the real name being "seine net." It consists of a net varying in length from 140 to 170 yards, and from 9 to 14 yards deep. Its value is about L.4, 10s. At each end is a short rope called the "bridle," kept stretched by a wooden spar called the "beam," to which is attached a rope varying from 100 to 200 fathoms in length, called the "drag rope." There are no buoys to the net, but it is kept upright in the water by means of pieces of cork, set about two feet apart. The whole apparatus is light and portable, and easily managed compared with the drift-net. The boats used with it are small, depending chiefly on oars, making no very long voyages, and commonly costing from L.10 to L.20, with crews of four or five men each, more men in proportion to the size of the boat being required for the work of hauling the trawl.

The trawl-net is used in different ways, according as it is to be worked from the shore, or from boats. For using from the shore, it is carried by the trawl boat to a place that appears favourable. The drag rope at one end of the net is handed to a party of men stationed on the shore, who hold it there while the boat rows off, the crew in her laying out the net in a semicircle, and when the net is all out, bringing the drag rope at the other end in with the boat to the land. A full and wide sweep is thus made with the net stretched to the full length of itself and the drag ropes, and a very considerable area of water is embraced by it. It resembles the net-and-coble salmon-fishing, formerly described, only on a much more gigantic scale.

[1] The above statement chiefly refers to, as it was derived from, our western shore. We believe that the designation of "a barrel of nets" originated from the practice which at one period prevailed of carrying the nets *in barrels*, from many places on the Firth of Clyde into the interior lochs, or other fishing-ground, with a view to the saving of stowage in the boats. But we have just been informed that the general custom, both in the west and east, now is for these portions of net to be made 50 yards long, and 15 score of meshes deep, with a back rope of 34 yards in length, and a gable line of about 11 yards; so that each single net now contains at least 374 square yards, and is about 33 feet in depth; of course the *drift* varies in length in accordance with the number of pieces which may be combined.

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On the boat reaching the land, the net is hauled in by the drag ropes, the parties at each rope coming nearer and nearer together to complete the circle. The net thus brings in with it fish of every description, herrings and all others, great or small, whatever may chance to exist within the circle. The object with the trawl-net is not to wait till the fish mesh themselves by entanglement, as with the drift-net, but to shift ground and make as many hauls as possible during the night, sweeping off the whole of the fish in succession at each spot visited.

When fish are not found inshore, the trawls are used in the middle of a loch or estuary, sometimes by means of two boats, sometimes with only one. When two boats are used, one remains fixed; the other rows away from it in a circle, till it comes round again to the first boat. The net is then hauled by the joint crews, the bottom being gathered in with the sides, so as to form a sack in the water. When one boat only is used, the tail end of the net is made fast to a buoy, the boat then rows away, swiftly passing out the net in a circle till it comes round again to the buoy, when the net is immediately hauled in after the same fashion as with the two boats.

This explanation is sufficient to show that trawl or seine net fishing does not require the capital, skill, or seamanship, of drift-net fishing, but that from its nature, and from the capture by single hauls of masses of fish, it gains immense and sudden prizes; while from the rapidity with which this net can be set and hauled again, as well as moved from place to place, a few trawling boats, in narrow waters and convenient situations, may, though only manned with landsmen and not fishermen, carry away many entire shoals of fish, having gone over in rapid succession all the best water. The use of the trawl or circle net, and the dragging a drift-net through the water, in the manner of trawling, for the purpose of taking herrings, are both prohibited by the 6th clause of the act 14th and 15th Victoria, cap. 26.

The drift-net and the trawl-net fishermen are greatly opposed to each other. The drift-net men are by much the most numerous, and wherever the trawl-net is used, whether it be on the west or east coast of Scotland, the same objections are stated against it, though in greater or less degree, according to locality. The drift-net men say (especially as regards Loch Fine, and other narrow waters), that trawling disturbs and disperses the shoal of fish as it enters from the sea, and scares it away. They call this "breaking the eye of fish," and they say that when the eye or centre of the shoal of herrings is broken in its progress up a loch, the body of fish are scattered and lost,—that they do not reunite in a shoal and continue to swim together after the manner of herrings, but are split up into separate fragments, which, thus detached from the main body, seek back to deep water or the open sea for safety. They say that the herring is a timid and easily frightened fish, and therefore, for the good of the fishing, that its capture should be effected without disturbance of the water, and by the quiet process of letting the fish mesh itself. Those thus caught remain in the net to all appearance swimming, and no shock is given to the shoal. Whereas trawl-nets are brought with violence against the main body, forcibly driving it back, with much disturbance in the lower parts of the water.

They further affirm that the operation of the trawl-net in catching large masses of fish of all sorts and sizes, and jumbling them up together, bruises and injures many, which being unsaleable, are left dead or dying in the water, thus destroying the fishing grounds. That the small fry of the fish are caught indiscriminately along with the full-sized parents, to the injury of the brood. That herring spawn is destroyed. That no trammel-nets can be set, because trawlers take possession of the bays, and the trawls would tear down any other nets placed there. That drift-nets in the same way are driven out of the bays and best places into the middle of lochs, and other unfavourable situations, because the trawl-net must inevitably foul the drift-net and destroy it, if it is used near it. That trawling-skiffs often come among the trains of drift-nets, where the crews trawl by making fast their drag ropes to the back ropes of the drift-nets, thus intercepting and carrying off the very fish that are about to be captured by the latter. That in moving about among the trains, these crews are frequently guilty of lifting the drift-nets, and stealing the fish. That from malice they often stab the drift-net buoys, and thus sink both nets and fish, which are thereby totally lost. That trawlers, in general, are not genuine fishermen (though of course there are individual exceptions), but interlopers, consisting of tradesmen, small farmers, farm servants, and other landsmen, who may have sufficient skill to manage a boat in fine weather, but who do not follow sea-fishing as a profession, although they may venture upon a kind of gambling speculation, with the chance of earning a twelvemonth's income by a few weeks' work. That they take from drift-net men the large class of herrings which were formerly caught by trammels, and which would be so caught again if trammels could be set. That the extravagant gains of great trawling hauls are thus monopolized by a few, and those not regular fishermen, while the same quantity of fish divided among men with trammels and drift-nets, would support and enrich the families of many real fishermen. That trawling can never be a general mode of fishing for herrings, as it is capable of being carried on only in certain localities, and under certain conditional circumstances, and thus the returns of such a system must always be confined to a few persons who are enabled by it to fill the markets suddenly with fish, from the enormous hauls they meet with. These, however, which are often very much the result of accident, deprive the established fisherman of his fair livelihood, by rendering his fish unsaleable except at prices which entail on him a positive loss. That in Loch Fine there has been a falling off in the quantity of fish since trawls were adopted, now not much more than a dozen years ago.

The trawl-net fishermen, on the other hand, deny all these allegations. They state that they are able to take larger and finer herrings than were ever known till the trawl was introduced. That this large herring is a slow swimming fish, which will mesh but seldom, and can only be caught with certainty by being forcibly pent up in a net. That herrings being a timid fish, will not mesh during the early summer nights, because there is too much light, and they see the drift-nets. To catch them at that time of year, therefore, they say they must be encircled by a trawl-net. That they also catch mackerel, and other sorts of fish, with the trawl-net, when fishing for herrings. That a small capital is made to produce a comfortable livelihood. That the produce of the sea is free to all, and as marine fish call no man master, they may be taken at any season, by whoever is able, and in whatever manner can be devised.

The trawlers also deny that the fishing has suffered from their operations, or that they interfere with drift-nets, or any other kind. On the contrary, they affirm that by working with their trawl-nets along shore, they often drive the herrings into the middle of the lochs, to be captured by the drift-nets laid out there, and from which they would otherwise escape.

While the statements of the two parties are thus opposite and conflicting, there is one point which admits of no doubt, viz., that trawling any kind of herring-net practically supersedes the provision of the act 48th Geo. III., cap. 110, sec. 12th, requiring the mesh to be one inch from knot to knot; for the act of drawing the net through the water in a circular form, immediately narrows the mesh below the inch-square, even though it should be in itself somewhat more than an inch from knot to knot. It is from this effect, and from the packing up of the net with a solid accumula-

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tion of fish, that under-sized herrings and fry are frequently taken and destroyed by the trawl-net. If trawl-net fishing for herrings could be admitted without detriment to the herring-fisheries, as is stated by its advocates, it seems to be unreasonable to maintain any legislative provision, such as that just cited, or to prohibit drift-net fishers from using any size of mesh they please.

The inch-mesh is universal over the coasts of Great Britain, and, we believe, is observed in Ireland. It forms an article in the fishery convention with France, and fishermen of that country are required to adhere to it as strictly as our own. Whatever may have been its origin, the meaning of the regulation is obvious, viz., that full and sizeable herrings should alone be caught, and the young allowed to grow. The medium mesh of an inch accomplishes both these objects. How far they are important, or could be continued were all restriction upon the size of mesh removed, is matter of opinion and conjecture; but a mass of netting in the sea, with meshes drawn close and thick, certainly seems calculated to debar the natural progress and circulation of the fish among the different boats, must undoubtedly capture the young fry, and would probably, from its increased visibility of cordage, be apt to frighten away the heavy shoals of mature fish. The existing regulation for the size of mesh is popular, and seems to be approved of by fishermen of all classes.

Trawling for herrings is practised on the west coast of Scotland, chiefly in Loch Fine, the Kyles of Bute, the Firth of Clyde, especially on parts of the Ayrshire coast, and in Loch Ryan. It is also occasionally resorted to in some of the other Lochs. The most active and determined trawlers on the west coast are those of Tarbert, a fishing village halfway up Loch Fine. On the east coast of Scotland, it is chiefly practised in the Firth of Forth, and occasionally, but slightly, in the Firth of Tay, Beauly Firth, and Firth of Cromarty. The act for its suppression is frequently enforced.

There is, undoubtedly, some disadvantage in establishing a uniform standard of mesh, or one general law for herring-fishing, that admits of no exceptions; for there may be cases, either in respect of the time of year, or of a breed of herrings of smallish size, where a power of relaxation and adaptation might be found beneficial. There is reason to believe, that in certain lochs of the Highlands, and in other parts, herrings occur below the average dimensions, although quite fit for food, and that for these, nets with meshes less than an inch from knot to knot, might be used with advantage.

When a train of drift-nets has remained in the water for a sufficient length of time to allow the herrings *to mesh*, the nets are raised, and the fish carefully shaken out of each successive portion as it is taken on board. This is a much better plan than one too frequently followed, of allowing them to remain among the meshes till the whole mass is taken to the shore. By the former practice, the fish are much less liable to be bruised or broken, and so do not so soon become soft or tainted. An additional advantage is that the nets are all the sooner ready to be spread out or hung up to dry. If not intended to be consumed in the fresh state, the sooner salt is applied to herrings the better, as it secures the adhesion of the scales, so important to the after appearance of the fish. For this purpose salt should be sprinkled over them, as they are emptied in successive portions from the cran measure into the great receiving or gutting trough. All herrings should if possible, be gutted, cured, and packed on the day they are caught.

All along the inner harbour, and in almost every street and quay, of the town of Wick, as well as within many large inclosed yards and covered buildings, there are numerous square wooden boxes as big as ordinary-sized rooms, the containing sides, however, being only two or three feet high. Into these huge troughs the herrings are carried from the boats as soon as possible after they arrive. There they are all tumbled in helter-skelter, in a long-continued stream of fish, until the boats are emptied or the troughs are filled. Then come troops of sturdy females of various ages and complexions, each armed with knife in hand, who range themselves around the fishy chambers,—the process of gutting immediately commences, and is carried on with such ceaseless and untiring activity, that the unaccustomed eye can scarcely follow the quickness of their manipulations. One woman will eviscerate about two dozen of herrings in a minute; and when nearly 2000 of them are working at that rate, with but brief intermission from early morning till the close of day, the amount of disembowelment may be more easily imagined than described. This important process is effected in the following manner:—The practitioner takes a herring in her left hand, its back lying in her palm, and inserts the point of her knife into the near side of the neck, bearing well down upon the backbone, and making the weapon protrude a little through the other side. She then gives the knife a turn, and pulling it outwards and upwards, with an opposing pressure of the thumb, she draws forth in the first place the gills, stomach, and intestinal canal, and tosses them into an adjoining barrel. She then inserts the knife a second time, and by a peculiar twitch removes what is called the crown gut, or cæcal appendages, and liver. There are thus two actions performed, each of which seems to occupy about a second of time. This is the ordinary Scotch, and we prepresume English, practice. The Dutch method is somewhat different. They leave in the crown gut, and so with them a single pull suffices to remove whatever is to be taken away. This latter mode is partially followed in this country, as being best adapted for the continental market, where it is believed that the crown gut has a powerful influence in improving the flavour of the fish, and where the appearance of the herring is held to be injured if it is removed.

These fair gutters usually work together in little companies of two or three, so that while one is filling a measure with her gutted fish, another carries them off to be *roused*, as it is called, that is, cast into other vats or barrels, then sprinkled with salt, then more herrings and more salt, and next a brawny arm plunged among them far above the elbow, thus mingling them together, and so on till the space is filled. They may lie a longer or shorter time in this state, according to the supply of labour at command, and the immediate necessities of gutting and rousing; but the next usual step in the routine is for a third hand to remove those herrings from the second vats or vessels, and re-salt and pack them carefully, every successive row crossing at right angles that which precedes it. Herrings intended for the foreign market are usually arranged with their backs downwards, while those for the Irish market are preferred when packed flat, or more upon their sides. Each row gets a fresh sprinkling of salt until the barrel is filled. The head of the cask is then laid loosely on, the contents being allowed to settle down, or *pine*, as it is called, for a time; which they soon do so considerably as to admit of each cask receiving another row or two, with additional salt, before being closed by the cooper. The barrels should then be headed up, tightened in the hoops, laid upon their sides, and placed under cover, so as to be shaded from the sun's rays, which are injurious to the fish. They should also be rolled half over every second or third day, until they are bung-packed; which process, if the after intention is to receive the official brand of the board of fisheries, must not be sooner performed than after the lapse of ten free days from the date of capture. "When the pickle has been sufficiently poured off, a handful of salt, if required, should be thrown around the inside of the barrels, and the herrings should be pressed close to the inside of the casks, and additional fish,

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of the same description and date of cure, should be packed in until the barrel is properly filled; after which it should be flagged, headed, blown, and tightened, and the curing marks scratched upon the sides. The barrel may then have its pickle poured in, and be finally bunged up."[1]

An injurious practice prevails among our people, of allowing the gutters and packers to stand "idle in the market-place" until a large quantity of herrings is poured into the curing vats. Every hour lost between the capture of the fish and their being salted down into the barrel produces injury. The gloss of their marine freshness passes away as the dew of the morning, and it is the preservation of this natural splendour, so to say, from the cure commencing on board ship almost the minute they are taken from the water which causes Dutch herrings to be so highly prized. The British curer should bear this in mind, and remember that while he is in possession of great local conveniences from curing on shore, these may be counterbalanced by some disadvantages which it requires care to obviate. The Dutch herrings escape all exposure to the sun. They pass at once from the sea to the salting tub. But the British fish are frequently for hours beneath a burning sun, while the boats are delayed, by calms, or are beating up to their desired haven against adverse wind and tide. The curers too often add to this delay, by waiting till such an ample supply has been accumulated as will enable all the gutters and packers to set to work simultaneously. The general adoption of the plan of placing sheds or covers of some kind over the curing tubs, would be very advisable. In many places the curing under cover is totally disregarded, although it is obvious that the reputation of British herrings can never be perfectly kept up while improvements so easy to accomplish are neglected. Our Banff herrings began to rank high at an early period, in consequence of their careful cure; and even now, when no doubt many other places are equal, it is the custom of several of the Caithness curers to brand the word "Banff" upon their barrels, although they have no connection with that locality. The cause which we have seen assigned for the excellence of the Banff herrings is, that they are usually caught in small or moderate quantities, so that more pains can be bestowed upon their preparation. On the Caithness coast they are often got in overpowering numbers, so that some of them may be too hastily cured. Of course, the presence and inspection of the fishery officer checks any bad effect from this, so far at least as concerns the guarantee afforded by the application of the crown brand.

We understand that the commissioners of the Board of Fisheries, with a view to test the progress that has been made in the cure of British herrings, instituted, some seasons back, in Edinburgh, a trial of different sorts, compared with some of the finest Dutch samples. The conjoined kinds were submitted to the taste of competent judges, and were privately marked by distinguishing cyphers unknown to those who had to give their opinion. There was no other clue to the quality than what the skill of the judges could supply. The result was highly satisfactory: for by a unanimous decision, two classes of British herrings—viz., Maties and Crown Full Brand—were declared to be superior to Dutch of the finest quality, which had been imported expressly for this competition. Of course, we must not build too much on this, as a few selected and super-excellent samples may not necessarily indicate, or at least prove, the superiority of the entire cure considered in relation to some hundred thousand barrels. That superiority, from causes already mentioned, probably still abides with the Dutch. The experiment was renewed during an after year, and was conducted in the same public manner, and with similar arrangements to prevent the judges from having any clue to the kind of herring set before them. The result of this other trial was different, although it testifies to the freedom from favouritism of those concerned. The Dutch were decided to be the best, though only in a slight degree; and a more searching trial on the succeeding day proved that the prize, determined with difficulty, had been justly awarded. To an ordinary purchaser, it is probable that no difference would have been perceptible, and the British barrels from which the samples had been taken would no doubt have passed for Dutch, as they often do in the Rhenish provinces. But in every particular these Dutch herrings showed a delicacy of treatment evidently the result of long experience, and the nicest tact. In both trials, however, it was evident how prodigious an advance had been made within a few years in the British mode of cure, when it was able to stand successfully, under the keenest criticism, so close a comparison with that of the Dutch.

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The lively interest taken by the Dutch government in the furtherance of their fisheries, is shown by the fact of their placing superintending men-of-war to aid their fleet of fishing vessels while engaged off the coasts of Scotland and the Shetland Islands. They also order a government steamer of great power and large dimensions (the "Cerberus" was heavily armed, with a crew of 100 men), to attend upon the boats, and receive on board the early catch of fish, so that these may be carried off with all expedition, to secure the highest price in the continental markets. The importance of the Dutch fishery was perceived by the nation at an early period, and their inroads upon our own resources were bemoaned by many writers. "It maketh much," says Sir John Burroughs, in his *Sovereignty of the British Seas*, "to the ignominy and shame of our English nation, that God and nature offering to us so great a treasure, even at our own doors, we do, notwithstanding, neglect the benefit thereof, and by paying money to strangers for fish of our own seas, impoverish ourselves to make them rich." When the population of the States General was estimated in 1669, it was found that, out of a total of 2,400,000 persons, 450,000 were either fishermen or connected with the building and equipment of ships and boats belonging to the fisheries. So the pensionary De Witt scarcely exaggerated when he stated that every fifth man in Holland earned his subsistence by the sea, that the country derived her main support from it, and that the herring-fishery ought to be regarded as the right arm of the republic. In the height of her prosperity and power, it is said that not less than 3000 boats of various kinds were employed off her own coasts, besides 800 vessels, of from 60 to 150 tons burden, occupied on the British seas in the capture chiefly of cod and ling. She had, moreover, between the mouth of the Thames and Buchan-Ness, a fleet of 1600 busses engaged in the herring-fishery, and employing so many minor vessels in the carrying of salt and cured fish, that the total number of shipping amounted to 6400, calculated to give employment to 112,000 mariners and fishermen. The Dutch themselves admitted that the wealth and strength of the United Provinces were derived from their sea-fisheries, the importance of which was emphatically indicated by an expression in common use among them, that "the foundation of Amsterdam was laid on herring bones." Of course there was this essential difference between the Dutch and ourselves, that they grew no grain, were scarce of cattle, and possessed few manufactures, and so depended largely on the produce of the sea, to enable them to effect the required exchanges with other countries.

[1] *Directions for taking and curing Herrings, and for the curing of Cod, Ling, Tusk, and Hake.* By Sir Thomas Dick Lauder, Bart. Edinburgh, 1846.

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We shall now endeavour to illustrate by tables the extent and value of our herring fishery.

Abstract of the Total Quantity of White Herrings Cured, Branded, and Exported, in so far as the same have been brought under the cognizance of the Officers of the Fishery, *from the* 1*st of June* 1809, *when the system hitherto in force for the Encouragement and Improvement of the British Herring Fishery took place, to the* 31*st of December* 1854; *distinguishing each Year as under, and the Countries to which they have been Exported. The Periods are calculated as ending* 5*th April each year up to* 1845, *and from* 1845 *they are calculated as ending* 5*th January. After* 1850 *the Table includes Scotland and the Isle of Man only.*

PERIODS.	Total Cured.	Total Quantity of Herrings Branded.	Total Quantity of Herrings Exported.			Grand Total Exported.
			To Ireland.	To other places in Europe.	To places out of Europe	
	Barrels.	Barrels.	Barrels or Crans.	Barrels.	Barrels.	Barrels.
1810	90,185	34,701	28,014	...	7,834	35,848
1811	91,827	55,662	28,212	...	9,921	38,133
1812	111,519	58,430	30,417	4,730	27,672	62,820
1813	153,488	70,027	57,980	11,046	40,699	109,725
1814	110,542	38,184	43,061	23,943	51,399	118,403
1815	160,139	83,376	49,635	35,891	55,778	141,305
1816	162,651	116,436	29,456	15,563	62,668	107,688
1817	192,343	140,018	36,341	44,432	57,855	138,628
1818	227,691	183,089	53,386	43,896	65,057	162,339
1819	340,894	270,022	89,704	52,333	85,125	227,162
1820	382,491	309,700	101,109	64,302	88,104	253,516
1821	442,195	363,872	125,445	89,524	79,836	294,805
1822	316,524	263,205	102,719	34,752	77,485	214,956
1823	248,869	203,110	56,528	38,002	75,914	170,445
1824	392,190	299,631	116,747	40,231	82,652	239,630
1825	347,665	270,844	96,409	35,029	70,577	202,016
1826	379,233	294,422	121,386	28,167	67,519	217,073
1827	288,495	223,606	78,735	16,701	70,970	166,406
1828	399,778	279,317	109,108	24,489	78,061	211,659
1829	355,979	234,827	107,651	28,280	69,944	205,875
1830	329,557	218,418	89,680	24,302	67,672	181,654
1831	439,370	237,085	130,300	61,655	72,947	264,903
1832	362,660	157,839	128,458	31,100	57,941	217,499
1833	416,964	168,359	114,137	47,556	58,991	220,684
1834	451,531	178,000	149,254	55,852	66,987	272,093
1835	277,317	85,079	73,960	34,050	50,795	158,805
1836	497,614	192,317	168,960	48,451	55,982	273,393
1837	397,829	114,192	102,968	46,777	39,520	189,265
1838	507,774	141,552	139,095	57,388	38,674	235,158
1839	555,559	153,659	149,926	64,870	24,934	239,730
1840	543,945	152,231	157,359	82,515	12,647	253,522
1841	557,262	154,189	150,517	90,951	8,668	250,137
1842	667,245	190,922	187,953	91,069	5,713	284,736
1843	623,419	162,713	165,327	120,136	6,336	291,800
1844	665,359	182,988	127,770	181,953	3,793	313,516
1845	526,032	140,632	120,293	143,754	2,326	266,373
1846	532,646	142,473	127,027	113,678	2,488	243,194
1847	607,451	156,278	102,585	148,363	4,765	255,714
1848	562,743	146,500	102,690	142,532	4,959	250,181
1849	644,368	153,944	78,262	168,049	3,682	249,994
1850	770,698	213,286	78,889	257,108	4,258	340,256
1851	544,009	172,024	66,138	198,403	2,367	266,908
1852[1]	594,031	201,636	81,340	182,659	205	264,204
1852[2]	498,787	160,159	60,414	221,979	1,133	283,526
1853	778,039	248,136	95,339	242,853	4,438	342,630
1854	636,562	211,844	121,883	237,893	1,919	361,696

N.B.—In the Six Years ending 5th April 1815, the Bounty on Herrings Cured Gutted was 2s. per Barrel, while there was a Bounty at the same time of 2s. 8d. per Barrel, payable by the Excise on the Exportation of Herrings, whether Cured Gutted or Ungutted, but which ceased on the 1st June 1815; in the Eleven Years ending 5th April 1826, the Bounty on Herrings Cured Gutted was 4s. per Barrel; in the Four succeeding Years, the Bounty was reduced 1s. per Barrel each Year till the 5th of April 1830, when it ceased altogether, and has not since been renewed.

It will be seen from the preceding abstract that the quantities exported, whether to Ireland or elsewhere, vary greatly. The recent falling off in Ireland followed the famine, and the failure in the potato crop. Salt herrings cannot be eaten alone, and the common Irish have little or no bread. The exports to "places out of Europe" were chiefly to the West Indies, but the changed condition of what was formerly the slave population of those islands has caused a great alteration in their diet. They do not now voluntarily purchase to any great extent what they were formerly *supplied with* in their state of bondage. It will be observed, however, that the general exports to the European markets are on the whole greatly on the increase, and no doubt, under an alteration of import duties, admit of an enormous enlargement.

Our next table exhibits in local detail the fishing of 1854, of which season the totals are given at the close of the preceding abstract.

An Account of the Total Number of Barrels of White Herrings which have been Salted or Cured on Board of Vessels fitted out for the Fishery, or Cured by Fish-Curers on Shore, in Scotland and the Isle of Man, in the year ended 31*st December* 1854; *distinguishing the Districts where Landed or Cured.*

Leith	6,695½	Wick	126,625¼
Eyemouth	25,353	Lybster	41,550
Greenock	8,456	Helmsdale	31,785
Glasgow	12,410	Cromarty	14,783
Rothesay	2,399½	Findhorn	31,566
Inverary	20,632½	Banff	46,995¼
Loch Carron and Skye	2,056	Fraserburgh	44,215
Loch Shildag	658	Peterhead	66,691
Loch Broom	1,328	Anstruther	77,646½
Stornoway	31,515	Isle of Man	13,797¾
Shetland Isles	9,009		
Orkney Isles	20,394½	Total	636,562
In addition to the above, there was taken and sold or otherwise consumed in Scotland and the Isle of Man, the following amount of barrels or crans, not cured, but disposed of fresh, viz.			103,789
Thus making a grand total for 1854 of			740,351

We owe to Mr Alexander Wellmann, a Prussian merchant, some valuable statistical information regarding the conditions of the herring market at Stettin, to which port a large proportion of our Scotch herrings are exported. The following is a note of the quantities of the Stettin importations for a period of twenty-seven years:—

Years.	Barrels.	Years.	Barrels.
1824	15,468	1838	40,209
1825	18,160	1839	49,456
1826	7,695	1840	73,949
1827	15,082	1841	50,732
1828	13,478	1842	62,135
1829	14,449	1843	143,659
1830	33,866	1844	105,097
1831	13,077	1845	81,189
1832	31,837	1846	104,372
1833	31,711	1847	112,260
1834	19,060	1848	103,402
1835	26,875	1849	147,103
1836	28,227	1850	116,538
1837	36,309		

Mr Wellmann records his opinion as follows regarding the advantage of the brand:—"I take this opportunity of stating, that the official brand of Scotch *crown* and *full* branded herrings obtains the greatest confidence, not only in our market, but also in the interior of Germany, where the meaning of that brand is understood, and my firm belief, and also that of other people engaged in this branch of business, is, that it would be injurious to the trade should the brand cease to exist, for Scotch herrings are only sold in small quantities in this market and the neighbourhood; they are chiefly sent great distances, of from 100 to 800

[1] For year ending 5th January.

[2] For year ending 31st December.

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miles English, into the interior of Germany and Poland, either by orders or offers, without the assistance of commission merchants, for the great expense of forwarding them does not permit any commission to a third party. The great distance likewise prevents dealers from inspecting the herrings on the spot here, who therefore make their purchases solely on their trust in the official brand, knowing that the fish must be selected well, and properly cured; that the barrels be of the legal size; and that they require to be well and tightly made before the brand can be affixed.

"These herrings are generally forwarded by crafts which are often six to eight weeks on their passage, and it frequently happens that a great fall in the market takes place during that time, and, should the official brand be removed, dealers in the interior might easily take advantage of such falls, for it would not be difficult to find complaints, such, for instance, that the fish were not properly selected or well cured, that the fish had too much or too little salt, or that the barrels were of a smaller size (for no one can then say of what size the barrels require to be), and, as most herrings are sold on credit, they would consequently be often stored at the risk and the expense of the shipper, and perhaps in markets where that person who purchased them is the only dealer.

"Part of the present business consists of consignments by the curer in Scotland, who receives an advance when the herrings are shipped; and my opinion is, that this advance will cease to be given as soon as the official brand is removed, as our merchants here are then unable to judge what proceeds they will receive out of them when sent to the interior, and consequently the Scotch curer must feel it seriously whenever this brand is taken away, as he would not be able to embark so much capital, and from him it must show its influence upon the fishermen, and those people connected with the fishing."[1]

We may here observe, that although a large quantity of Norwegian herrings are exported, they are not cured under the superintendence of the government, and as therefore no certain reliance can be placed on their quality, they are scarcely ever sent into the interior of continental countries, but, so far at least as Prussia is concerned, are chiefly consumed at Stettin and the neighbouring provinces, from whence dealers are able to proceed for a detailed inspection; and hence Norwegian fish are in general more difficult to be sold than Scotch. We understand that in some places in Norway local boards have of late been formed, and already herrings shipped from these ports both find quicker sales, and are sent further into the interior. The sale of Norwegian herrings, however, greatly depends upon the prices of Scotch fish, for when the latter are low the former are more difficult to be disposed of, and the Prussians prefer our fish to those of the Norwegian cure, because they are of superior quality, better preserved, and the barrels contain a greater number. Dutch herrings must still be regarded as belonging to "high art" in their style of cure, but the difference in price is great, and so the Scotch kind abroad still find a readier sale. But the improved cure, and increased cheapness, of our fish, continue to operate in our favour, as the following, from the preceding report, will suffice to show:—

In 1834,	barrels	of Dutch herrings received at Stettin,			4,546
...	...	of Norwegian	do.	...	53,981
...	...	of Scotch	do.	...	19,960
In 1850,	...	of Dutch	do.	...	568
...	...	of Norwegian	do.	...	12,507
...	...	of Scotch	do.	...	116,538[2]

In 1849 our exportation to Stettin amounted to 147,103 barrels. That year had produced the most extraordinary take of herrings ever recorded in Scotland, and so gave the power, while Prussia afforded the opportunity, of an ex-

[1] Letter to George Traill, Esq., M.P., in *Report on British Fisheries* for 1850.

[2] We may here note the duties charged abroad on herrings. In the confederated states of Germany (the *Zollverein*), the present duty is one dollar per barrel, equal to about 3s. sterling. *Austria* charges 2 gulden 30 kreutzers per cwt., making about 15s. sterling per barrel, a prohibitory duty nearly equal to what is often the prime cost. *Russia* (we know not her present views regarding the Baltic trade) used to make a difference in her tariff between Scotch and Norwegian herrings, the former paying an import duty of 1 ruble 30 cops silver per barrel, equal to about 4s. 6d. sterling, the Norwegian being charged only 35 cops silver, being about 1s. 3d. sterling per barrel. The duty in *Poland* was formerly lower on Scotch herrings, but has been raised to that of Russia since the 1st of January 1851, and we have lost, in the meantime, a good market as concerns that "nationality." In *France* the duty is from 37s. to 40s. per barrel, more than double the actual price, and so of course it is entirely prohibitory. In *Naples* it is still nearly as high as it formerly was in Belgium (from 12s. to 15s. per barrel), but we know not its precise amount at the present time. From *Spain* and *Portugal* we understand that our herrings are excluded, we presume by reason of the excessive duty. None are ever sent there. The Spaniards, however, consume the finest of our cured cod and ling, on which the duty is as follows:—*Direct from the place of cure,*—In Spanish vessels, L.6, 10s. per ton; in British vessels, L.8, 13s. per ton. *Indirect, or from a port not at the fishing-ground,*—In Spanish vessels, L.10 per ton; in British vessels, L.12 per ton.

The following are the duties on British fish in *Belgium*, according to the convention, signed at London, March 22, 1852:—

	Francs.	Cents.
Herrings—pickled or drysalted, per barrel of 150 kilogramme, gross weight,	13	...
Others, per thousand,	8	...
Lobsters—destined for the national beds, per 100 francs value,	6	...
Others, per 100 francs value,	12	...
Oysters—destined for the national beds, per 100 francs value,	1	...
Others, per 100 francs value,	12	...
Cod—pickled or drysalted, per barrel of 150 to 160 kilogramme, gross weight,	22	50
Stockfish—per 100 kilogramme,	1	...

The above conditions were to come into operation on the 10th of April 1852. They are a modification and reduction of the former tariff, but certain of the duties are still so high as to be in fact prohibitory. The weight of 150 kilogramme is about equal to that of a Scotch barrel of herrings, and the imposed duty is 13 francs, or about 11s. sterling. Under such a tax on importation the trade will never open. The smoked or red herrings are more leniently dealt with, a duty of 8 francs, or 6s. 8d., on the thousand, being one farthing on every three herrings. This, it is thought, may admit of an increased consumption, and produce a profit to our people. Flanders is noted for its industrial and concentrated population, and has now the advantage of a net-work of railways. Within a circumference of half a day's journey we have the following large cities:—Brussels, 140,000 inhabitants; Ghent, 100,000; Liège, 80,000; Louvain, 55,000; Antwerp, 90,000; Bruges, 60,000; Mons, 30,000; Namur, 30,000; Malines, 50,000;—to say nothing of several others of less note. An established taste for herrings, of whatever kind or colour, among such hordes of hungry people, would assuredly be of great advantage both to them and us.

We may add that the *transit duties*, that is, the tax imposed on transmission into countries not pertaining to the place of original importation, have an influential bearing on prices and profits. Prussia has recently reduced her transit duties on herrings from 1s. 6d. to 4½d. per barrel. Those imported by Russia used to be charged 10 silver groschen, equal to about 1s. sterling per barrel, on the Oder as well as Vistula, while on the river Elbe it is only 2½. Holland charges about 3s. sterling per barrel for the transit of herrings on the Rhine. Denmark levies a duty of 3d. sterling per barrel on all herrings that pass through the Sound. Hanover charges one halfpenny per barrel for such as pass the Elbe at Stade.

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cessive exportation. The capture during the season of 1849 was as follows:—

	Barrels.
Total quantity cured,	770,698
Total quantity disposed of fresh,	381,281
Grand Total,	1,151,979

Of the former, 149,505 barrels were cured at Wick alone. Of the latter the following large quantities were taken and sold fresh at the stations of the Firth of Forth, viz.:—

	Barrels.
Anstruther,	24,243
Eyemouth,	34,243
Leith and Burntisland,	20,000
	78,486

Yarmouth[1] produced during that same season 113,574 barrels of fresh herrings, the London station 26,224, and Liverpool and the Isle of Man 27,600. The grand total for 1849 includes the English stations, which yielded 209,362 barrels, leaving for Scotland and the Isle of Man 942,617 barrels. The season of 1853 was also very productive, the returns for that year, exclusive of the English stations, giving a total of 908,800 barrels.

The value and importance of this great fishery as a seafaring occupation and marine nursery are too obvious to require mention. The following abstract is exclusive of the English stations, and also of between four and five thousand men engaged in the *export* fishing trade.

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Abstract, for Scotland and the Isle of Man, of the Number of Boats, &c., employed in the year 1854.

Districts to which the Boats belong.	Boats.	Fishermen.	Coopers, Gutters, Packers, Labourers, &c.	Total of Persons.	Fish-curers.
Leith	354	1,166	813	1,979	25
Eyemouth	225	951	701	1,652	47
Greenock	591	1,828	669	2,497	33
Glasgow	41	82	142	224	20
Rothesay	561	1,624	418	2,042	76
Inverary	1,062	3,189	1,114	4,303	65
Loch Carron and Skye	751	2,589	2,924	5,513	36
Loch Shildag	307	1,085	103	1,188	87
Loch Broom	570	2,120	394	2,414	11
Stornoway	418	2,178	1,146	3,324	28
Shetland Isles	665	3,162	1,106	4,268	61
Orkney Isles	606	2,471	1,224	3,695	48
Wick	853	3,227	3,535	6,782	197
Lybster	260	1,300	919	2,219	46
Helmsdale	181	597	867	1,464	21
Cromarty	271	1,125	2,080	3,205	17
Findhorn	317	780	815	1,595	27
Banff	776	2,853	1,454	4,307	56
Fraserburgh	439	1,466	1,634	3,100	39
Peterhead	656	2,095	2,785	4,880	76
Anstruther	500	2,099	2,604	4,703	68
Isle of Man	487	2,372	128	2,500	43
Total	10,891	40,359	27,475	67,834[2]	1,127

The following table exhibits the amount of tonnage, the number of men employed, and the value of the materials engaged in the cod and ling fishery, as well as in that of herrings, during the season of 1854.

Districts.	Tonnage and Number of Men employed in carrying Salt for the Fisheries direct from Liverpool or from foreign parts.		Tonnage and Number of Men employed in Exporting Herrings or Cod and Ling Fish.		Tonnage of Boats employed in the Herring or Cod and Ling Fisheries.	Value of Boats employed in the Fisheries.	Value of Nets employed in the Fisheries.	Value of Lines employed in the Fisheries.	Total Value of Boats, Nets, and Lines employed in the Fisheries.
	Tonnage.	*Men.*	*Tonnage.*	*Men.*	*Tons.*				
Leith	1,600	160	1,900	190	3,540	L.10,620	L.10,089	L.1,062	L.21,771
Eyemouth	2,600	162	318	36	2,200	7,700	7,900	2,640	18,240
Greenock	935	71	158	13	1,667	6,556	10,348	1,849	18,753
Glasgow	300	20	1,366	112	100	300	500	35	835
Rothesay	155	13	123	82	2,284	7,300	8,350	1,500	17,150
Inverary	698	56	97	22	3,638	12,566	22,735	1,451	36,752
Loch Carron and Skye	750	76	38	5	4,200	8,200	15,000	1,200	24,400
Loch Shildag	240	30	...	...	1,563	4,173	12,650	619	17,413
Loch Broom	210	21	...	...	3,426	8,330	13,898	1,142	23,370
Stornoway	698	64	1,441	163	3,312	5,615	5,560	5,725	16,900
Shetland Isles	1,264	102	1,610	133	2,192	6,285	4,710	4,310	15,305
Orkney Isles	1,106	87	2,558	247	3,681	9,670	12,607	1,103	23,380
Wick	6,705	521	14,018	1,012	7,996	22,840	31,615	2,370	56,825
Lybster	1,872	124	2,181	170	2,084	7,170	9,950	263	17,383
Helmsdale	1,645	75	2,524	190	1,578	3,320	4,400	750	8470
Cromarty	1,027	53	1,187	107	1,893	4,800	13,300	500	18,600
Findhorn	1,048	86	2,540	190	2,249	4,800	9,850	1,560	16,210
Banff	2,270	170	3,455	279	5,890	27,417	29,584	7,804	64,805
Fraserburgh	1,471	105	3,424	239	2,527	6,923	14,580	3,695	25,198
Peterhead	3,020	190	2,846	201	7,834	18,855	16,228	5,910	40,993
Anstruther	2,567	171	793	52	4,750	22,500	30,567	8,924	61,991
Isle of Man	468	47	377	56	3,810	19,890	19,274	3,512	42,676
Total	32,649	2,404	42,954	3,499	72,414	L.225,830	L.303,666	L.57,924	L.587,420[3]

[1] The Yarmouth herring-fishery is chiefly an autumnal and early winter one, but it seems that a summer season is also enjoyed there. We are informed by Mr John Miller, the intelligent inspector-general of the fisheries, that "some of the Scotch boats returned, after an absence at the Yarmouth herring-fishery, with L.300. These boats have now (2d August 1855) begun business again off Dunbar."

[2] The above numbers are exclusive of the southern fishing stations. When these were included the total amount was much larger. Thus, in 1846 the report, as made up for the preceding season, gives the total number of persons employed as 99,065, besides 1530 curers, and nearly 5000 men engaged in the export trade. The great season of 1849 gave occupation to 98,326 persons, besides 1619 curers, and 6101 men engaged in the export trade. It ought also to be borne in mind, while estimating the importance of our fisheries as a field of industrial occupation, that these high figures are altogether irrespective of the numerous individuals employed in our salmon-fisheries, and in those for turbot, flat-fish, mackerel, and many other kinds.

[3] The returns of the board of fisheries now give estimates only for Scotland and the Isle of Man. When London, North Sunderland, and Whitby were included, the value of the materials employed was of course much greater. Thus, for the season ending in the winter of 1846, the boats were estimated at L.702,206; the nets at L.481,262; the lines at L.92,371;—making a total of L.1,275,839.

Scotch sea-fisheries.

We shall now say a few words regarding *red herrings.* It is believed that the taste for these, when the smoking process is carefully performed, is on the increase, and might be turned to the advantage of Scotland. Our north-eastern stations, say from Peterhead to Caithness inclusive, have great facilities in the way of cure as well as capture, and it ought to be understood that the super-excellence of a red herring depends both on its original state and its subsequent mode of treatment. Smoked herrings are made from salted ones. They are converted pickles, so to say, and have not always been in the best condition when committed to the brine. But if allowed to lie there for any considerable length of time, they must be steeped in fresh water to remove a portion of the salt previous to smoking, and it is by this intervening process that the quality is deteriorated. There is a certain period during which herrings may be removed at once from the pickle to the smoking-house, and there is a longer time after which they must be steeped. Yarmouth bloaters are among the best of things, but our southern neighbours labour under this great disadvantage, that their fishing is chiefly a winter one, when herrings are seldom in prime condition, while along our north-eastern shores they are caught in the months of July and August, when these fish are in perfection. The cure may be good, but the southerns have not the same articles to begin with. To use Mr Thomson's illustration, a Holstein or Yorkshire ham may have every attribute of excellence in the cure, but as the animal has not lived in the woods of Westphalia, so its flesh has not the sweetness and flavour imparted by the acorn.

A larger outlay of capital is called for to carry on a manufactory of smoked herrings than simply to cure with salt and pack into barrels. It takes a house of considerable size to hang what may make up 300 barrels at one time. The herrings must hang on the smoking-spits for three weeks, and as the prime of the fishing lasts only about six weeks, the house can be filled only twice, if a lengthened lie in pickle and the steeping process are to be avoided. To do the thing in perfection, the produce of a considerable number of boats would be required at once, because if a fortnight from the commencement of the fishing were allowed to elapse in the filling of the smoking-house, the curer would have no opportunity of filling it a second time, at least with freshly pickled and unsteeped fish. A change is said to have taken place in the taste for red herrings. They were formerly preferred of a silvery brightness instead of a golden yellow, and to produce the former state only a few hours' smoking was required. Of course these did not keep, and were sorely distressed by sultry weather. But the taste is now tending rather towards a complete cure, that is, a three weeks' careful and continuous smoking, after which a herring of originally sound constitution will keep almost as long as an Egyptian mummy, and be much better eating in the end.

Along our eastern shores the smoking of herrings is carried on extensively in Aberdeen, Montrose, Dundee, Burntisland, and Leith, and in the west chiefly in Glasgow. But these localities are not stations for the herring-fishery itself, and so many of our curers have smoking establishments at Peterhead, Fraserburgh, and Wick, where they can obtain a full and immediate supply of fresh fish.

The supply of the home market with red herrings and bloaters was formerly engrossed by the Scotch and Yarmouth curers, but it is yearly becoming more extended, and shared by a greater number. Transit by steam is so rapid from the Hebrides, Shetland, Orkney, and other distant places, to railway harbours, and thence by railways into England, that smoking-houses for preparing bloaters are now in use in Liverpool, Manchester, and Birmingham. At distant fishing stations the herrings for bloaters are slightly mixed with salt in dry barrels or boxes, from which the pickle is allowed to escape to prevent over saltness; they are speedily forwarded to the smoking premises, where they are washed (but not soaked), and smoked for 24 to 36 hours, and then despatched as bloaters per rail for London, or the other great English markets, in barrels, half barrels, or in small boxes each containing 100 herrings. Many of the fishing stations are now regularly frequented by English buyers, who daily purchase and forward herrings to England, fresh or slightly sprinkled with salt, according to the season. When the supply of fresh fish is large, or greater at market than the demand, the surplus is often purchased at a reduced price by resident English dealers, smoked for 24 or 36 hours, and again presented at market in small neat baskets as prime Yarmouth bloaters. This gives the English adventurer an advantage over his distant competitors, which he is not slow to avail himself of, and he frequently sells a part of his own fish at an unremunerating figure, and purchases by agents the fish sent to market on consignment at a lower price than he paid for his own at the curing station.

Another class of red herrings are salted for thirty-six or forty-eight hours at the curing station. They are then washed, but not soaked, and smoked for twenty-one or twenty-eight days. These keep well, and have much of the rich flavour of Westphalian ham. Herrings made into reds for exportation, or those smoked in winter for home use, having been salted and cured in pickle, are soaked from thirty to thirty-six hours, according to quality, and then smoked for periods varying from three to four weeks. The soaking of the fish greatly injures their flavour.

Pilchard-fishery.

Having closed our account of the greatest of our fresh and salt water fisheries, those for salmon and herring, we shall now proceed to notice the capture of other species, of great though unequal value.

One of the most important of our southern fisheries (of which we have as yet said nothing) is that for *pilchards* (*Clupæa pilchardus*), a species nearly related to the herring. This fishery is pursued chiefly off the coast of Cornwall. The fish show themselves while swimming past the Scilly Islands in the month of July, and are there caught with a drift-net. They then advance inland in August, during which month the principal or "in-shore" fishing begins. They visit various parts of the coast until October or November, and then disappear till the ensuing summer. They are occasionally caught off the south-western part of Devonshire, and also near the most southern portion of Ireland, but northwards of these two points they are seldom seen off any other district of the British shores.

"The first sight," says an eye-witness, "from the cliffs, of a shoal of pilchards advancing towards the land, is not a little interesting. They produce on the sea the appearance of the shadow of a dark cloud. This shadow comes on, and on, till you can see the fish leaping and playing on the surface by hundreds at a time, all huddled close together, and all approaching so near to the shore, that they can be always caught in some fifty or sixty feet of water. Indeed, on certain occasions, when the shoals are of considerable magnitude, the fish behind have been known to force the fish before literally up to the beach, so that they could be taken in buckets, or even in the hand, with the greatest ease. With the discovery of the first shoal, the active duties of the 'look-out' on the cliffs begin. Each fishing-village places one or more of these men on the watch all round the coast. They are called 'huers,' a word said to be derived from the old French verb *huer*, to call out, to give an alarm. On the vigilance and skill of the 'huer' much depends. He is therefore not only paid his guinea a-week while he is on the watch, but receives besides a perquisite in the shape of a percentage on the produce of

Pilchard-fishery.

all the fish taken under his auspices. He is placed at his post, where he can command an uninterrupted view of the sea, some days before the pilchards are expected to appear; and, at the same time, boats, nets, and men, are all ready for action at a moment's notice.

"The principal boat used is at least fifteen tons in burden, and carries a large net called the 'seine,' which measures 190 fathoms in length, and costs L.170, sometimes more. It is simply one long strip, from 11 to 13 fathoms in breadth, composed of very small meshes, and furnished all along its length with lead at one side and corks at the other. The men who cast this net are called the 'shooters,' and receive 11s. 6d. a week; and a perquisite of one basket of fish each out of every haul. As soon as the 'huer' discerns the first appearance of a shoal, he waves his bush. The signal is conveyed to the beach immediately by men and boys watching near him. The 'seine' boat (accompanied by another small boat to assist in casting the net) is rowed out where he can see it. Then there is a pause, a hush of great expectation on all sides. Meanwhile, the devoted pilchards press on—a compact mass of thousands on thousands of fish swimming to meet their doom. All eyes are fixed on the 'huer;' he stands watchful and still until the shoal is thoroughly embayed in water which he knows to be within the depth of the 'seine' net. Then, as the fish begin to pause in their progress, and gradually crowd closer and closer together, he gives the signal; the boats come up, and the 'seine' net is cast, or, in the technical phrase, 'shot' overboard.

"The grand object is now to inclose the entire shoal. The leads sink one end of the net perpendicularly to the ground, the corks buoy up the other to the surface of the water. When it has been taken all round the fish, the two extremities are made fast, and the shoal is then imprisoned within an oblong barrier of network, surrounding it on all sides. The great art is to let as few of the pilchards escape as possible while this process is being completed. Whenever the 'huer' observes from above that they are startled, and are separating at any particular point, to that point he waves his bush; thither the boat is steered, and there the net is 'shot' at once. In whatever direction the fish attempt to get out to sea again, they are thus immediately met and thwarted with extraordinary readiness and skill. This labour completed, the silence of intense expectation that has hitherto prevailed among the spectators on the cliff is broken. There is a great shout of joy on all sides—the shoal is secured!

"The 'seine' is now regarded as a great reservoir of fish. It may remain in the water a week or more. To secure it against being moved from its position in case a gale should come on, it is warped by two or three ropes to points of land in the cliff, and is, at the same time, contracted in circuit, by its opposite ends being brought together and fastened tight over a length of several feet. While these operations are in course of performance, another boat, another set of men, and another net (different in form from the 'seine'), are approaching the scene of action. This new net is called the 'tuck;' it is smaller than the 'seine,' inside which it is now to be let down for the purpose of bringing the fish closely collected to the surface. The men who manage this net are called 'regular seiners.' They receive ten shillings a-week, and the same perquisite as the 'shooters.' Their boat is first of all rowed inside the seine net, and laid close to the seine boat, which remains stationary outside, and to the bows of which one rope at one end of the 'tuck-net' is fastened. The 'tuck' boat then slowly makes the inner circuit of the 'seine,' the smaller net being dropped overboard as she goes, and attached at intervals to the larger. To prevent the fish from getting between the two nets during this operation, they are frightened into the middle of the inclosure by beating the water at proper places with oars, and heavy stones fastened to ropes. When the 'tuck' net has at length travelled round the whole circle of the 'seine,' and is securely fastened to the 'seine' boat at the end, as it was at the beginning, everything is ready for the great event of the day—the hauling of the fish to the surface.

"Now the scene on shore and sea rises to a prodigious pitch of excitement. The merchants, to whom the boats and nets belong, and by whom the men are employed, join the 'huer' on the cliff; all their friends follow them; boys shout, dogs bark madly; every little boat in the place puts off crammed with idle spectators; old men and women hobble down to the beach to wait for the news. The noise, the bustle, the agitation, increases every moment. Soon the shrill cheering of the boys is joined by the deep voices of the 'seiners.' There they stand, six or eight stalwart, sunburnt fellows, ranged in a row in the 'seine' boat, hauling with all their might at the 'tuck' net, and roaring the regular nautical 'Yo-heave-ho!' in chorus! Higher and higher rises the net; louder and louder shout the boys and the idlers. The merchant forgets his dignity, and joins them; the 'huer,' so calm and collected hitherto, loses his self-possession and waves his cap triumphantly. . . . The water boils and eddies; the 'tuck' net rises to the surface, and one teeming, convulsed mass of shining, glancing, silvery scales, one compact crowd of thousands of fish, each one of which is madly endeavouring to escape, appears in an instant. The noise before was as nothing compared with the noise now. Boats as large as barges are pulled up in hot haste all round the net; baskets are produced by dozens: the fish are dipped up in them, and shot out, like coals out of a sack, into the boats. Ere long the men are up to their ankles in pilchards; they jump upon the rowing benches, and work on, until the boats are filled with fish as full as they can hold, and the gunwales are within two or three inches of the water. Even yet the shoal is not exhausted; the 'tuck' net must be let down again and left ready for a fresh haul, while the boats are slowly propelled to the shore, where we must join them without delay.

"As soon as the fish are brought to land, one set of men, bearing capacious wooden shovels, jump in among them, and another set bring large hand-barrows close to the side of the boat, into which the pilchards are thrown with amazing rapidity. This operation proceeds without ceasing for a moment. As soon as one barrow is ready to be carried to the salting-house, another is waiting to be filled. When this labour is performed by night, which is often the case, the scene becomes doubly picturesque. The men with the shovels, standing up to their knees in pilchards, working energetically; the crowd stretching down from the salting-house across the beach, and hemming in the boat all round; the uninterrupted succession of men hurrying backwards and forwards with their barrows through a narrow way, kept clear for them in the throng; the glare of the lanterns giving light to the workmen, and throwing red flashes on the fish as they fly incessantly from the shovels over the side of the boat, all combine together to produce such a series of striking contrasts, such a moving picture of bustle and animation as no attentive spectator can ever forget."[1]

The fish are then carried to the curing-house, on the floor of which they are laid, with alternate layers of salt. There they remain "in bulk" for five or six weeks, during which time a quantity of oil, salt, and water, drips from them into wells perforated in the centre of the stone floor on which they lie. When taken out of "bulk," they are washed clean in salt water, and packed in hogsheads, which are shipped to Penzance, and other places, for exportation.

[1] *Rambles beyond Railways, or Notes in Cornwall taken a-foot.* By W. Wilkie Collins. P. 148.

Mackerel-fishery.

The trade is chiefly to the shores of the Mediterranean—Italy and Spain being the great foreign markets. The home consumption is next to nothing. Of course the value varies, but the average wholesale price may be stated at about 50s. per hogshead. The general export is about 22,000 hogsheads. The quantity sometimes taken is almost incredible. As many as 2200 hogsheads have been secured in a single seine, and Borlase mentions even 3000 as the result of a single capture. The number of pilchards to a hogshead was formerly 3500, it afterwards fell to 3000, and has since been reduced to about 2500, although they are not individually counted. According to Mr Yarrell, an instance has been known of 10,000 hogsheads being taken ashore at one spot in a single day, thus providing the enormous multitude of twenty millions of living creatures drawn almost at once from the briny deep for the sustenance of man.[1]

We know not the present value or importance of the pilchard-fishery, but so far back as 1827, when the bounty began to be withdrawn, the conditions were as follows:—number of seines employed, 186; not employed, 130; total number of seines, 316; number of drift boats, 368; men employed on board drift-boats, 1600; number of men employed on seines at sea, 2672; number of persons on shore to whom the fishery affords direct employment, 6350; total number of persons employed in the fishery, 10,521; cost of seines, boats, &c., used in the fishery, L.209,840; cost of drift-boats and nets, L.61,400; cost of cellars for curing, and other establishments on shore for carrying on the fishery, L.169,175; total capital invested directly in the pilchard-fishery, L.441,215. The outfit of a seine amounts to about L.800. A string of drift-nets will cost about L.6; the net and the boat from L.100 to L.150; but these are used throughout the year for the other purposes of fishing.[2]

Although white bait, sprats, shads, and others, belonging to the herring family (*Clupeidæ*), should here be mentioned as of some importance in our fisheries, we must pass them over without any detailed notice, in consequence of our want of space.

The mackerel (*Scomber scomber*), though long regarded as a migratory fish, may be taken, like the herring, on some part of our coast, during every month throughout the year. Those got in the months of May and June are considered to be in higher condition than such as are brought to table either in autumn or early spring. Of all fishes, they deteriorate the most rapidly after death, and so, to be eaten in perfection, they ought to be consumed as soon as caught. Mackerel were first allowed to be cried through the streets of London on a Sunday in the year 1698, and the practice has continued ever since. It seems the habit of this fish to present itself ever and anon in the most extraordinary quantities, and the greater the pity that it should so speedily lose its natural flavour. "Mackerel," says Mr Yarrel, "were so plentiful at Dover in 1808, that they were sold at sixty for a shilling. At Brighton, in June of the same year, the shoal of mackerel was so great, that one of the boats had the meshes of her nets so completely occupied by them, that it was impossible to drag them in; the fish and nets, therefore, in the end sunk together, the fishermen thereby sustaining a loss of nearly L.60, exclusive of what the cargo, could it have been got into the boat, would have produced. The success of the fishing in 1821 was beyond all precedent. The value of the catch of sixteen boats from Lowestoffe, on the 30th June, amounted to L.5252; and it is supposed that there was no less an amount than L.14,000 altogether realized by the owners and men concerned in the fishing of the Suffolk coast.[3] In March 1833, on a Sunday, four Hastings boats brought on shore 10,800 mackerel, and the next day two boats brought 7000 fish. Early in the month of February 1834, one boat's crew from Hastings cleared L.100 by the fish caught in one night."[4] This was an earlier appearance than usual. During the last-named year a large quantity of fine mackerel were shown in the London markets in the second week of February. They were cried through the streets of the metropolis, three for a shilling, in the middle of March, and had then been plentiful for a month.

The usual mode of fishing for mackerel is by a drift-net 120 feet long and 20 feet deep. It is corked at the top, but has no leads below. It is made of fine twine, the size of the mesh being about two inches and a half, or rather more. From twelve to eighteen of these nets are attached to each other lengthways, by being tied along a thick rope called the drift-rope. When arranged for setting, a large buoy attached to the end of the drift-rope is cast into the sea, the vessel is put before the wind, and, as she makes way, the rope with the nets attached is passed over the stern, till the whole is run out. The drift-rope is then shifted from the stern to the bow of the vessel, after which she rides as if at anchor, while, at the sametime, the conjoined nets, sometimes a mile and a half long, are thereby kept strained, or in a straight line. When a large shoal, or *schul*, as it is called in Cornwall—

> "In sculls that oft
> Bank the mid sea,"

says Milton—shows itself, the congregation is encompassed by a small meshed seine-net, after the pilchard mode already mentioned, and are lifted on board the boats in flaskets. Sometimes the whole mass is hauled bodily ashore upon the beach. As mackerel will bite at almost any bait, quantities are likewise killed by hook and line. A slice cut from the side of one of themselves, near the tail, is a successful lure for its quondam companions, and even a slip of red leather or scarlet cloth, will slay its hundreds. The boat is kept in progress under sail, and a fresh breeze is advantageous.

Cod-fishery.

We shall now devote a few columns to the consideration of the cod-fishery. Although it might be supposed that, amid the exhaustless resources of the almost illimitable sea, the production of the finny tribes would not be greatly influenced by the actions of the human race, there seems to be no doubt that constant fishing tells upon these tribes to a certain extent, just as it is known to do more largely on those of narrower waters. By the statements of fishermen in general, it appears that the boats are almost everywhere obliged to go farther from the land than formerly before they find fish; and it is hence assumed, either that these have changed their ground, or that the places near the shore have been to a certain extent exhausted by over-work.[5] Of this there is no doubt, that much longer voyages are now undertaken in connection with the cod-fisheries than of old. Expeditions of smacks and other vessels to Davis' Straits to fish for cod, have been set agoing of late years, with various success. English smacks have made trips to Iceland, landing their fish, as they brought them home, at Stornoway in Lewis. Some were kept alive in wells of the smacks, but the greater part were salted. From

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[1] Pennant, while referring to the great capture of pilchards recorded by Borlase, has committed the extraordinary mistake of reckoning 35,000 fish to a hogshead, instead of 3500.

[2] Yarrell's *British Fishes*, vol. ii., p. 105.

[3] Messrs C. and J. Paget, in their *Natural History of Yarmouth and its Neighbourhood*, state that, in 1823, 142 lasts of mackerel were taken there. A last is 10,000. This makes 1,422,000 individuals.

[4] *British Fishes*, vol. i., p. 126.

[5] Sometimes local changes of a contrary kind occur. Thus, Mr Yarrell (writing about 1837) informs us that formerly the Gravesend and Barking fishermen captured no cod nearer than the Orkneys or the Dogger Bank, but that "for the last two or three years the supply for the London market has been obtained by going no farther than the Lincolnshire and Norfolk coasts, and even between that and London, where previously very few fish could be obtained."—*British Fishes*, vol. ii., p. 147.

Cod-fishery.

two smacks alone 27,000 cod-fish were landed. This cod-fishing off the Icelandic shores has long drawn the attention of the French, and has been actively and successfully prosecuted by them. There seems no reason why the British should not be at least equally adventurous in the same quarter. Vessels sailed from Shetland for the Faroe Isles in 1851, and one of these returned with as much cod and ling as when dried weighed thirty tons. Our cod and ling fisheries may be said to be of a much more stationary character than that for herrings. Though the value may be sometimes suddenly affected by the occasionally great success of the far northern captures just referred to, the annual yield of our own coasts seems very uniform.

It has been bountifully ordained, that while fish of the herring family usually most abound in summer and autumn, those of the *Gadidæ*, including cod, haddock, whiting, and several others, all more or less remarkable for the excellence of their flesh, are in best condition during the colder season of the year. The common cod (*Morrhua vulgaris*) is of the highest intrinsic value, and is providentially spread over a great expanse of the European seas, from Iceland almost to Gibraltar. It does not enter the Mediterranean, but all along the eastern shores of North America and its islands, from the 40th to the 66th degree, the supply is countless and inexhaustible. It is fortunately a fish of great voracity, and so is easily taken with a variety of baits. The usual mode of capture is by long deep-sea lines, with hooks fastened at regular distances along their whole length by shorter cords called snoods. The latter are six feet long, and are placed about twelve feet apart. Of course variations occur in the practice of particular places. Buoys and small anchors are fixed to each end of the line, which is shot across the run of the tide. An improvement was suggested many years ago by Mr Cobb, who was sent to Shetland by the commissioners of the fisheries. He attached a small piece of cork within about a foot of the hook. This suspended the bait, and prevented its lying concealed from the fishes' view by the inequalities of the ground, and also kept it more clear from the attacks of crabs and star-fish. A deal of hand-line fishing is also practised for cod, haddock, and and other white fish. Each fisherman has two lines armed with a pair of hooks, kept apart by a piece of wire or whalebone, and *leaded* so as to keep the bait near the ground. Cod inhabit deep water, and are usually fished for in from 25 to 40 or 50 fathom. Many cargoes are kept alive in welled-smacks, and are carried from great distances to the vicinity of the metropolitan markets. We once took occasion to visit one of those vessels at Stromness in Orkney. She was sloop-rigged—a capital sea-boat—went extremely fast—and measured 62 tons, old register. The skipper said he thought he would have no chance with a good yacht in light winds, but that in heavy weather he would keep a fair place with anything. The well was immediately abaft the mast, boarded off from the rest of the vessel, and communicating with, and receiving its water directly from, the sea beneath, by means of numerous perforations in the bottom of about two inches in diameter. Its length backwards from the mast seemed about ten or twelve feet, and its breadth nearly that of the sloop itself. The well was capable of holding about fifty score of live cod, and there were about ten score in it at the period of our examination. They seemed rather softened and subdued by their captivity, and came ever and anon with a lazy heave to the surface, showing their great flat heads, dim unexpressive eyes, and gaping mouths. Though heavy and stupid in their aspect, they seemed to have their senses about them, and speedily seized upon and swallowed such portions of shell-fish as we dropped into their watery chamber. To produce perpetual change in the waters of the well, these vessels are usually either anchored in a tideway, or one of the sails is kept partially set, so as to produce a constant heaving motion, and a consequent circulation of the briny flood. The fish are often confined in this way for a fortnight or three weeks, and if they show any symptoms of sickliness, the usual medical routine is reversed in their case,—they are killed first and cured afterwards. These sloops venture with their cargoes no farther up the Thames than Gravesend, beyond which the influence of the intermingling fresh water would prove destructive. From that point they are conveyed to market in boats with closed wells filled with sea-water. During all this lengthened period of confinement they seldom give them any food, although those we saw seemed well inclined to eat, from the rapid voracity with which they gobbled up our limpets.

Cod-fishery.

Although the deep-sea and hand-line fishing are thus of importance in affording to the fish-eating public a salubrious supply in firm and fresh condition, it is the quantity of cured cod and other allied kinds which constitutes their chief mercantile importance.

Abstract of the Total Quantity of Cod, Ling, or Hake, Cured and Exported, in so far as the same have been brought under the cognizance of the Officers of the Fishery, *from the* 10*th October* 1820, *when the system hitherto in force for the encouragement and improvement of the Cod and Ling Fishery took place, to the* 31st *December* 1854, *distinguishing each Year as under. From* 1822 *to* 1844 *inclusive, the periods are calculated as from* 10*th October to* 5*th April. They then run from* 5*th April to* 5*th January, up to* 1852 *inclusive. From* 5*th January* 1851 *and onwards, the quantities noted are for Scotland and the Isle of Man only.*

YEARS.	Cod, Ling, or Hake Cured.		Cod, Ling, or Hake Exported.	YEARS.	Cod, Ling, or Hake Cured.		Cod, Ling, or Hake Exported.
	Cured Dried.	Cured in Pickle.	Cured Dried.		Cured Dried.	Cured in Pickle.	Cured Dried.
	Cwts.	Barrels.	Cwts.		Cwts.	Barrels.	Cwts.
1822	...	...	19,578	1839	85,279	10,051	26,701
1823	...	...	19,398	1840	93,560	6,053	29,656
1824	...	...	23,098	1841	91,494	9,480	30,550
1825	...	...	14,087	1842	76,849	7,038	25,293
1826	69,136	5,621	7,281	1843	77,207	6,431	23,737
1827	95,161	9,025	14,051	1844	92,813	5,123	35,476
1828	82,515	6,142	13,208	1845	83,919	1,726	28,815
1829	81,321	6,819	20,587	1846	92,323	5,037	29,352
1830	101,914	8,836	16,369	1847	90,783	6,341	34,435
1831	37,674	2,950	11,920	1848	86,624	6,247	25,662
1832	50,293	3,779	20,168	1849	85,463	6,810	22,608
1833	58,461	6,467	14,754	1850	98,903	6,588	24,154
1834	52,710	5,522	16,298	1851	90,658	5,032	22,304
1835	44,152	3,767	10,632	1852[1]	92,083	7,019	17,141
1836	38,040	6,276	10,992	1852[2]	102,976	6,886	18,994
1837	66,892	7,273	10,195	1853	105,596	5,122	22,650
1838	84,996	10,303	22,166	1854	109,684	6,166	19,557

N.B.—The books of the Board of Fisheries do not exhibit the total quantity of cod, ling, or hake *cured* till the year commencing 5th April 1825. The bounty, from the commencement of this Abstract to the 5th of April 1830, was 4s. per cwt. for fish cured dried, and 2s. 6d. per barrel for fish cured in pickle, taken by the crews of vessels or boats *not* on the tonnage bounty; while the bounty for vessels licensed for the cod and ling fishery, or the *tonnage* bounty, was 50s. per ton, for tonnage and cargo to the 5th of July 1826; 45s. from thence to the 5th of July 1827; 40s. to the 5th of July 1828; and 35s. to the 5th of April 1830, when the bounties ceased altogether, and have not since been renewed.

Stornoway, and the Orkney and Shetland Islands, are the principal stations for these fish. Thus, of the 109,684 cwt. taken at the twenty-one stations of which our cod districts consist, 73,707 cwt. belonged to the three localities just named. The quantity of individual fish of the cod and ling kind killed in 1854 was 3,523,269, of which 1,385,699 were from the Shetland Islands. The great exports of dried fish

[1] For the year ended 5th January.

[2] For the year ended 31st December, and so also for the two subsequent years.

Cod-fishery.

are also from these islands. Thus, there were last year exported to Ireland 7855 cwt., and to continental Europe 5630 cwt., making 13,485 cwt. out of 19,557, the entire quantity exported. Besides these weights of cured fish, there was 58,042 cwt. disposed of fresh, making a grand total of 167,726 cwt., cured or fresh, and 6166 barrels preserved in pickle.

The following is the mode of curing dried cod, &c., practised in our northern isles. The fish are generally gutted before they are brought ashore. As soon as they are landed, the *splitter* with a large knife cuts them open from head to tail, and extracts the upper half of the back-bone. He then hands them over to the *washer*, who, with a brush and sea-water, cleanses them of every particle of blood. When all the fish have been in this way split and washed, they are allowed to drain, and then come into the hands of the *salter*, who places a stratum of salt at the bottom of a large wooden vat, and over it a stratum of fish, and so on alternately till the vat is filled. Above all are laid heavy stones to keep the fish beneath the pickle. After the lapse of some days they are taken out, well washed, and brushed from shoulder to tail, and put up in small heaps, called *clamps*, to drain. They are then spread upon the shingly beach slantingly, with the back undermost, exposed to the action of the sun and air; and after being thus alternately clamped and exposed singly, they are built into larger stacks, called steeples, which, for the sake of equal pressure, are themselves occasionally taken down and rebuilt, by which means the fish that were uppermost at one time, are undermost at another. As soon as this drying, or pining, as it is technically called, is completed (as indicated by a white efflorescence appearing on the surface, named the bloom), the fish are transported to a dry cellar lined with wood, and piled up closely, if not speedily shipped off to market.[1] We may add, that the Yorkshire curers, who are thought the best in the world, dry their fish on wooden flakes, raised on posts three feet high, of such length as may be requisite, and about four feet wide. There is a platform of cross bars at the top, placed six inches asunder, on which the fish are laid. The great advantage of this method is, that it preserves the fish perfectly clean, while, owing to the current of air passing underneath, the process of drying goes on as rapidly below as above. It also prevents the fish being sunburnt, blistered, or scalded, when first laid out, as not unfrequently happens if they are suddenly placed upon a stony beach in a hot day. When nothing but the beach is available, great care should be taken not to lay the fish out, for the first time, when the stones are too warm. Fish prepared for the Spanish market (where they are in great demand) ought to be rather lightly salted, of a pure greenish colour and transparent aspect, and very hard dried.

As the greatest cod-fishery in the world is carried on over the banks of Newfoundland, we shall here give a sketch of the *modus operandi*, as from a recent eye witness. The fish are all caught with hooks, and, as usual, from the bottom. Each fisherman has a strong line of from 60 to 70 fathoms in length, to which is attached a lead of a cylindrical shape, weighing about five pounds. From this proceeds the "pennant," which is a cord about twice the size of the line, and three feet in length. To the lower end of the pennant, and attached to it by a small copper swivel, is the "craft," which is a stout cord about 2½ feet in length, having three strips of whalebone laid around it at the middle, where it is attached to the swivel of the pennant. The whole is then serried or wound round with tarred twine. On each end of the craft is a smaller swivel, into which the gauging of the hooks is attached. The whalebone serves to keep the hooks about a foot apart, so there is little danger of their becoming entangled with each other.

Other sea-fisheries.

The men arrange themselves on the windward side of the deck, throw over their leads, and unreel their lines, till the lead rests on the bottom. It is then drawn up, so that the hook will touch the bottom with the down pitch of the vessel. They lean over the bulwarks, patiently awaiting a bite, which is known by a slight jerk on the line. They then give a sudden pull, in order to hook the fish, stand back, and haul in the long line, hand over hand, until the fish comes up to the surface, when he is taken on deck, unhooked, and thrown into a square box, which each man has fastened by his side, called a "kid." The hooks are then baited and hove over again, and the fisherman, while the line is running, picks up the fish caught and cuts out his tongue.

Towards night the fish are counted out from the kids, each one separately, and thrown into a large kid near the main hatch, called the "dressing kid." They are counted aloud as they are thrown along, and each man is required to keep his own account, and report to the skipper at night, who keeps a separate account for each man on the log-book. The dressing-gang, consisting of a "throater," a "header," a "splitter," and a "salter," now commence dressing down. After passing through the hands of the first three, they assume somewhat the shape seen in market. They are then passed down between decks to the salter, who puts them up in kenches or layers, laying the first tier on the bottom of the hold, and building up with alternate layers of salt and fish till the kench reaches the desired height. The decks are then washed down, sails taken in, and the vessel anchored for the night.[2]

The haddock (*Morrhua æglefinus*) now deserves a brief notice. This fish is of great value, from its excellence and frequency combined. It may be traced everywhere along the coasts of Great Britain and Ireland, the largest and finest being taken in Dublin Bay, and off the Nymph Bank. The haddock is extremely abundant on our eastern English shores from Yarmouth to the Tyne, and occurs plentifully on the same side of Scotland. This fish does not exist either in the Baltic or Mediterranean. It swims in great shoals, and not unfrequently shifts its stations, probably from the necessity of a change consequent on the consumption of food. The mode of capture is with long lines and hand-lines; and where the trawl-net is in use for other fish, the haddock, which, like the majority of the bearded fishes, feeds near the ground, is frequently taken by the trawl.

In the north-east of Scotland many people prepare these fish, not only for their own use, but also for sales, to a very large amount, at their own firesides, by appropriating a space in their chimneys, where the heat and smoke are applied without in any way interfering with the other domestic arrangements; and in those districts where wood is not to be had, peat or turf is used, and answers every purpose.

The fish, when freed from the head and intestines, is split, washed, and thoroughly cleaned from all impurities. It is then put in salt from one hour to five, and smoked and dried from six hours to twelve, the degrees of salting and smoking being modified according to the size and thickness of the fish, and the length of time it may be required to preserve it for consumption. At Findon in Aberdeenshire, from whence the "Finnans" derive their name, the fishermen use nothing but turf in the smoking process. Three hundred fish can be prepared at an ordinary-sized domestic fireside at one time. The split fish are hung from timber rods, which are passed across their upper or widest

[1] See Hibbert's *Shetland Islands*, p. 519, and Wilson's *Voyage round Scotland*, vol. ii., p. 331.
[2] See Hunt's *Merchants' Magazine* for March 1855.

Other sea-fisheries.

part, so as to keep them extended; these rods are then placed across the space from the wall to the chimney-piece at either side of the hearth, and small quantities of damp turf being lighted beneath, the smoke performs its office by ascending the chimney. For a near market, where the fish are likely to be consumed in about four or five days, half an hour in salt or pickle, and four to six hours' smoking will be sufficient. To supply the markets not only of Aberdeen, but even of the great southern cities, great quantities of this description of fish are now prepared and sent off from many other northern villages besides Findon. The degree of cure is regulated by the time which must elapse before the article can be used, an additional half-hour or more in salt, and two or more hours longer smoking, being given if required. Attention is paid to the state of the weather, the distance from markets, and the taste of the consumers.

The commerce in this description of fish has greatly increased in Scotland, many having embarked in it on a large scale by erecting extensive curing-houses, and purchasing haddocks from numerous captors, who confine themselves almost solely to this department of fishing. The whole process, when performed upon the smaller scale, and by the country people, takes only a few hours; so that fish caught in the evening may be in a market many miles distant on the morning of the following day. The real Finnans are generally small, and of a pleasant pale yellow colour; but larger fish are cured at the great commercial stations, and in a way intended to admit of their being sent a longer distance, and keeping for a longer time.

The whiting (*Merlangus vulgaris*) is regarded by many competent judges as the most delicate fish of this family. It occurs around our coasts, and advances pretty far northwards from the Orkneys to Cape Clear. Large examples are caught upon the Dogger Bank,[1] as well as on the coast of Cornwall, and the southern and other shores of Ireland. The whiting is fished for with lines; and although taken almost all the year through, it is most abundant in mid-winter, by which time it makes its approaches to the spawning places, at no great distance from the shore, and may then be taken in larger quantities than usual, within from half a mile to three miles from shore.

The coal-fish (*Merlangus carbonarius*) is a larger and coarser species, which is spread far northwards, being well known off Spitzbergen and in Davis' Straits. It enters the Baltic Sea, and is very abundant in Scotland and among our western and northern isles, where the fry, fished for from the rocks, often afford good sustenance to the poorer classes. It rejoices in many names, being in its different stages and districts known as silloch, podley, cuddy, sethe, coal-fish, and gray-lord. It attains to a weight of from fifteen to thirty pounds, and is often salted, and cured dry—bringing, however, a lower price than its congeners.

The hake (*Merlucius vulgaris*) is another of the coarser kind, caught like the preceding by hook and line. It is less abundant in Scotland than along some of the southern shores of England. Portsmouth is largely supplied from the Devonshire coast. Mr Couch describes it as roving about the Cornish shores in a somewhat irregular way, and as being extremely voracious in its habits. It is often inclosed in the circle of the seine-net, along with the pilchards, and being sometimes left undisturbed for several days it gluts itself to its heart's content. Seventeen of these fish have been taken from the interior of a hake of ordinary size. It occurs around Ireland, and is so abundant in the Bay of Galway as to have given the name to that district, as marked in some ancient maps, of the *Bay of Hakes*. In the salted state it is exported to Spain, although itself common on the northern shore of the Mediterranean, where it affords considerable traffic, being packed up in aromatic plants, and transmitted to the towns of the interior.

The ling (*Lotus mola*) is a much finer fish. Large quantities are taken by hook and line from Cornwall and the Scilly Isles to Shetland. It is excellent when cured, is much used for home consumption, and is pretty largely exported to Spain.

The tusk (*Brosmius vulgaris*) is another highly-esteemed species. It is one of the best in the cured state, swelling out well when boiled, and separating into thick firm flakes. It is a northern fish, frequent in the Orkneys, and abundant in Shetland. According to Faber (to whom we owe so much information regarding northern species), it seems to possess less power of resisting the violence of the sea than the majority of fishes, as it is sometimes dashed ashore dead in incredible numbers on the coasts of the Faroe Islands and the south of Iceland. He adds that, "Jan Olsen" says, that the fresh fish is badly tasted, but when dried is the best of food. We have not the pleasure of being acquainted with Jan Olsen, but the former portion of his opinion is most erroneous, and must be corrected. Fresh tusk is one of the very best of all fishes, either in or out of the sea, and it is worth any man's while to make a voyage to the Shetland Isles (in themselves so interesting), for no other purpose than to eat it. Jan is really very wrong.

A few words must suffice for flat-fish. Of these we have in this country at least sixteen different kinds, the majority in good request as food. Plaice, flounders, dabs, &c., may pass without any special notice. The largest of all the flat-fish, or *Pleuronectidæ*, is the holibut (*Hippoglossus vulgaris*), a species which sometimes weighs from 300 to 500 pounds. It is a northern fish well known in Greenland, not unfrequent in the Scotch markets, but rarer as we proceed southwards.

Of smaller size, but far more delicate flavour, is the true turbot (*Rhombus maximus*), the finest of the flat fishes. Its localities are much more southern than those of the preceding. It is caught both by the long line system already described, and by trawling. The English markets are largely supplied from the various sand-banks which lie between our eastern coasts and Holland. The Dutch turbot fishery begins about the end of March, a few leagues to the south of Scheveling. The fish proceed northwards as the season advances, and in April and May are found in great shoals upon the banks called the Broad Forties. Early in June they surround the island of Heligoland, where the fishery continues to the middle of August, and then terminates for the year. At the beginning of the season the trawl-net is chiefly used, but on the occurrence of warm weather the fish retire to deeper water, and to banks of rougher ground, where the long line becomes indispensable. Although a considerable quantity of turbot is taken on various parts of our own coasts, a preference is said to be given in the London markets to those caught by the Dutch. According to a calculation made some years ago (in the preceding edition of this Encyclopædia), that nation was supposed to draw not less than L.80,000 a-year for the supply of our metropolitan market alone; while the Danes (to whom the outer shores of Scandinavia formerly pertained)

[1] As bearing upon the general character and condition of this famous bank, we make the following extract from an amusing and instructive article on the "London Commissariat," in the *Quarterly Review*. "No better proof that its stores are failing could be given than the fact that, although the ground, counting the Long Bank and the north-west flat in its vicinity, covers 11,800 square miles, and that in fine weather it is fished by the London companies with from fifteen to twenty dozen of long lines, extending to ten or twelve miles, and containing from 9000 to 12,000 hooks, it is yet not at all common to receive even as many as four score fish of a night, a poverty which can be better appreciated when we learn that 600 fish for 800 hooks is the catch for deep-sea fishing about Kinsale." No. CXC., p. 280, September 1854.

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charged us from L.12,000 to L.14,000 a-year for sauce, made from one million of lobsters exported from the rocky shores of Norway. Mr Yarrell informs us that about one-fourth of the whole supply of London turbot is furnished by the Dutch. There is good trawling, as well as long-line fishing for this highly-prized species, over two extensive sand-banks called the Varne and the Bridge—the one about seven, and the other about twelve miles from Dover, towards the French coast. Trawling for turbot is also extensively practised along the coast of Devonshire, from which supplies are sent to Bath and Exeter, as well as London.

The sole (*Solea vulgaris*), though a much smaller, is a highly esteemed species. It inhabits sandy shores around the coasts of both Britain and Ireland. Those of our south and west districts are of larger size and finer quality than such as occur off the north and east stations. Soles seldom take a bait, but are caught in enormous quantities by means of the beam-trawl. The principal grounds lie along the south coast from Sussex to Devonshire. Two very productive stations are Brixham and Torbay.

Although skate, eels, and several other fishes of some value, remain unnamed, we must here close a treatise which has extended to a greater length than was foreseen at its commencement. The importance of the general subject, and the multiplicity of its departments, must plead our excuse. We shall conclude with a brief extract, and one more tabular view.

"Next to the herring-fishery," says the writer already referred to, "the sea-harvest of most importance to the poor of London is that of sprats, which come in about Lord Mayor's day, and it is a popular belief that the first dish is always sent to the chief magistrate of the city. The plaice season succeeds that of sprats, with the interval of mackerel, which continues until the end of May, when Scotland and Ireland pass their salmon into the market. But where do all the lobsters come from? The lovers of this most delicious of the crustacean tribe will probably be astonished to learn, that they are mainly brought from Norway, France, and the Channel Islands. Orkney and Shetland do, it is true, contribute a few to the metropolitan market; but full two-thirds are reluctantly, and with much pinching and twisting, dragged out of the thousand rock-bound inlets which indent the Norwegian coast. The fighting, twisting, blue-black masses are taken as soon as purchased to what are termed 'the boiling-houses,' of which there are four, situated in Duck and Love Lanes, close to the market, and here, for a trifling sum per score, they change their dark for scarlet uniforms. They are all plunged into the boiling cauldron, basket and all, and in twenty minutes they are done. Crabs are cooked in the same establishments, but their nervous systems are so acute, that they dash off their claws in convulsive agony, if placed alive in hot water. To prevent this mutilation, which would spoil their sale, they are first killed by the insertion of a needle through their head. The lobster trade is mostly in the hands of one salesman, Mr Saunders, of Thames Street, who often has upwards of 15,000 consigned to him of a morning, and who causes no less than L.15,000 a-year to flow into the fishy palms of Norwegians for this single article of commerce."[1]

The following table of the total supply of fish to the London market, is from Mr Mayhew's work on *London Labour and the London Poor.*

Description of Fish.	No. of Fish.	Weight of Fish. lb.
Wet Fish.		
Salmon and salmon-trout (29,000 boxes, 14 fish per box)	406,000	3,480,000
Live cod (averaging 10 lb. each)	400,000	4,000,000
Soles (averaging ¼ lb. each)	97,520,000	26,880,000
Whiting (averaging 6 oz. each)	17,920,000	6,720,000
Haddock (averaging 2 lb. each)	2,470,000	5,040,000
Plaice (averaging 1 lb. each)	33,600,000	33,600,000
Mackerel (averaging 1 lb. each)	23,520,000	23,520,000
Fresh herrings (250,000 barrels, 700 fish per barrel)	175,000,000	42,000,000
Ditto in bulk	1,050,000,000[2]	252,000,000
Sprats	...	4,000,000
Eels from Holland (principally), England and Ireland (6 fish per lb)	9,797,760	1,505,280 127,680
Flounders (7200 quarterns, 36 fish per qtn.	259,200	43,200
Dabs (7500 quarterns, 36 fish per qtn.)	270,000	48,750
Dry Fish.		
Barrelled cod (15,000, 40 fish per barrel)	750,000	4,200,000
Dried salt cod (5 lb. each)	1,600,000	8,000,000
Smoked haddock (65,000 barrels, 300 fish per barrel)	19,500,000	10,920,000
Bloaters (265,000 baskets, 150 fish per basket)	147,000,000	10,600,000
Red herrings (100,000 barrels, 500 fish per barrel)	50,000,000	14,000,000
Dried sprats (9600 large bundles, 30 fish per bundle)[3]	288,000	96,000
Shell Fish.		
Oysters	495,896,000	...
Lobsters (averaging 1 lb. each)	1,200,000	1,200,000
Crabs (averaging 1 lb. each)	600,000	600,000
Shrimps (324 to a pint)	498,428,648	...
Whelks (227 to half bushel)	4,943,200	...
Mussels (1000 to half bushel)	50,400,000	...
Cockles (2000 to half bushel)	67,392,000	...
Periwinkles (4000 to half bushel)	304,000,000	...

(J. W.)

[1] *Quarterly Review* for September 1854, p. 280.

[2] We feel somewhat doubtful in regard to this enormous aggregate. It will be seen from our preceding exposition of the herring-fishery, that the entire recorded take for the whole of Britain (including the fish consumed fresh, cured in salt, and smoked as *reds*), amounted in 1849 to 1,151,979 barrels. This, allowing 800 to a barrel, would give *nine hundred million* of individual herrings, with above *twenty-one million* over. Now the quantities in the above table (including both barrels and bulk) would seem to show that the London market alone, and supplied chiefly from Yarmouth, receives an annual stock of fresh herrings amounting to *twelve hundred million* of individuals, with *twenty-five million* over. We have applied to the Board of Fisheries for the English returns for 1849, of herrings disposed of fresh, and find as follows:

	Barrels.		Barrels.
Bristol	3,500	North Sunderland	21,400
Isle of Man	10,000	Whitby	29,123
Liverpool	17,600	Yarmouth	113,574
St Ives	1,800		
Whitehaven	12,790	Making a total for the south country of	236,011
London	26,224		

This, at the rate of 800 to a barrel, gives only *one hundred and eighty-nine millions* of individuals, with above *two hundred thousand* over. Of these a considerable number (probably the majority of such as were caught upon the western coasts) would be consumed elsewhere than in London. We know not how much of the Yarmouth herrings "in bulk" may have been transported rapidly, and without record, but upon the whole we apprehend some exaggeration or mis-statement in the matter.

We desire in this place to express our obligations to the Hon. B. F. Primrose, secretary to the Board of Fisheries, and his assistants in office, for the readiness with which he and they have at all times aided us in our researches.

[3] We may note as follows (from the *Return of the quantity of fish sold at Billingsgate in* 1850) regarding certain species omitted from the above:—Turbot (from 2 to 16 lb. each) 2500 tons, or 800,000 fish. Brill and Mullet (3 lb. each) 1500 tons, or 1,220,000 fish.

Pearl Fishery. See Mollusca, § *Pearls;* and Pearl.

Whale Fishery. See *Balæna*, index to Mammalia.

FISHGUARD, a seaport-town of South Wales, county of Pembroke, 14 miles N. of Haverfordwest. It is called by the natives *Abergwaen*, from its situation at the mouth of the little river Gwaen, over which there is a good stone bridge. The town is small and ill-built, and in the older part of it the street is so ill constructed as to be extremely inconvenient for the passing of carriages. The harbour is capacious, and at all times easy of access, being unobstructed by shoals or bars, and sheltered by the bold promontories of Dinas Head and Penainglas. The bay extends from E. to W. about 3 miles, and from N. to S. more than a mile and a half. Its general depth is from 30 to 70 feet, and ships of the largest size may anchor in all parts of it with perfect security. The trade, however, is unimportant. About 2½ miles S. of the town a French force of 1400 men, under General Tate, landed on 22d February 1797, and next day surrendered to a few militia and volunteers not half their own number. Fishguard unites with Haverfordwest and Narberth in returning a member to parliament. Pop. (1851) 1757.

FISHING. See Angling, and Fisheries.

FISSIROSTRES. See index to Ornithology.

FISTULA was used by the Romans to denote any small pipe, a reed, &c.; and more particularly the shepherd's or Pan's pipe, which was a combination of reeds gradually decreasing in length and calibre, corresponding to the syrinx of the Greeks.

Fistula, in *Surgery*, a deep, narrow, and callous ulcer, arising generally from abscesses. It differs from a *sinus* in being callous, which the latter is not.

FITCH, a chick-pea, a vetch. See Agriculture, vol. ii., p. 328–9.

FITCHY, in *Heraldry* (from the French *fiché*, fixed), a term applied to a cross when the lower branch ends in a sharp point. The origin of this device is supposed to be, that the primitive Christians were accustomed to carry about crosses with them, and when they stopped at any place on a journey they fixed these portable crosses in the ground for the purposes of devotion.

FITZ, the old French word for *fils*, a son, and which, as a prefix to proper names, corresponds to the Celtic *Mac*, to the Hebrew *Ben*, and its Aramaic synonym *Bar*.

FITZHERBERT, Sir Anthony, a distinguished lawyer in the reign of Henry VIII., was born at Norbury in Derbyshire, but in what year is not known. He was educated at Oxford, passed rapidly through the lower grades of the legal profession, and in 1523 was made a puisne judge of the court of common pleas, an office which he held till his death in 1538.

Fitzherbert's works are—The Grand Abridgment collected by that most reverend judge Mr Anthony Fitzherbert, lately conferred with his own manuscript corrected by himself, together with the references of the cases to the book, by which they may be easily found, printed in folio by Pynson in 1514, by Wynken de Worde in 1516, and again in 1577; The Office and Authority of Justices of Peace, 1538, but often reprinted, the last edition being dated 1617; The Office of Sheriffs, Bailiffs of Liberties, Escheators, Constables, Coroners, and others, 1538; Of the Diversity of Courts, 1529; The New *Natura Brevium*, 1534, to which, in the last edition, published in 1794, 2 vols. 8vo, is added a commentary supposed to have been written by Chief-Justice Hale, with notes, references, and an enlarged index; Of the Surveying of Lands, 1539; The Book of Husbandry, 1534, reprinted several times in the reigns of Mary and Elizabeth. Of these works, five, in the order in which they are here enumerated, were, with the exception of part of the second, originally written in French.

FITZJAMES, James. See Berwick, Duke of.

FITZSTEPHEN, William, author of the earliest extant description of London, was of Norman extraction, but born in the English metropolis during the first half of the twelfth century. He became a monk of Canterbury, and filled various offices in the household of Thomas à Becket. When that prelate was murdered, Fitzstephen alone of his numerous clerks and attendants did not fly, but was an eyewitness of the whole transaction. His Description of London originally formed part of another work, entitled *The Life and Passion of Archbishop Becket.* Stow, in his *Survey of London*, has appended a translation of Fitzstephen's work; but the best edition of it is that of Dr Pegge, London, 1772. Fitzstephen in his work shows a considerable acquaintance with the best Latin authors, and even a certain knowledge of the Greek classics. He is believed to have died in 1190.

FIUME (Illyrian *Réka*, German *St Veit am Flaum*), a seaport-town of the Austrian dominions, formerly capital of the Hungarian district of Littorale, now of the palatinate of Fiume in Croatia. It is situated on the gulf of Quarnero, at the mouth of the Fiumara in the Adriatic, 38 miles S.E. of Trieste. It consists of an old and a new town, the former standing on a hill, and consisting of steep and narrow streets, with old and mean houses; the latter extending along the shore, and having wide, clean, and well-paved streets, and many handsome edifices. In the old town is a fine Roman arch, but so hemmed in by hovels as to be difficult of access. The church of St Veit is an elegant building, not unlike that of St Maria della Salute at Venice. The casino is a handsome edifice, containing coffee and ball rooms and a theatre. On an adjacent height stands the old castle of Tersat. Fiume has manufactures of linens, coarse woollens, leather, paper, sugar, rosoglio, wax, and earthenware. It has been a free port since 1722. Being the immediate outlet by sea for the produce of Hungary, it was early looked upon as a place of importance; and the emperor Charles VI. constructed a magnificent road, called *Carolina*, about 75 miles in length, between it and Carlstadt in Croatia, where the inland navigation, by means of the Culpa and the Save, terminates. In 1809 the *Luisen Strasse*, also leading from Fiume to Carlstadt, was opened, and is now the principal means of communication between those two places. Carlstadt communicates with the coast at Zeng by means of a third road, constructed by the emperor Joseph II., and hence called *Josephina.* Fiume, however, is not a place of extensive trade, being naturally much inferior to Trieste. The harbour is accessible only to vessels of small burden, large vessels being obliged to anchor about three miles from the shore. The chief exports are wheat, wine, tobacco, timber, rags, and hemp. Pop. 11,000.

FIXED AIR, carbonic acid gas. See Chemistry, vol. vi., p. 471, &c.

FIXITY, or Fixedness, in *Chemistry*, the opposite of volatility; or that property by which bodies resist dissipation by heat.

FIXMILLNER, Placidus, a learned German astronomer, was born at Achleuthen, near Linz in Austria, in 1721. In 1737 he entered the Benedictine monastery at Kremsmünster, where a few years later he was appointed professor of ecclesiastical law, an office which he held for forty years. His fame, however, rests chiefly on his astronomical learning. The abbot had caused an observatory to be erected in the monastery, and Fixmillner was appointed chief astronomer. When he first entered upon the duties of this appointment his acquaintance with astronomy was very defective; but by severe study and unremitting application he not only overcame the deficiencies of his early training, but even earned a very respectable place in the second rank of astronomical observers. The value of his observations on the planet Mercury was publicly acknowledged by Lalande. Fixmillner was also one of the first to determine the orbit of the planet Uranus. His principal astronomical works are his *Meridianus Speculæ Astronomicæ Cremifanensis*, 1766; *Decennium Astronomicum*,

1776. He likewise contributed a large number of papers to many of the scientific journals of his own and other countries. He died in 1791.

FLACCUS, Caius Valerius, a Roman poet, of whose personal history little is known. He was contemporary with Martial, who addressed one of his epigrams to him, in which he urges him to exchange literary for legal pursuits as more likely to lead to fortune. He seems to have been a native of Padua, though, from the names *Setinus Balbus* found appended to some MS. copies of his works, some writers have attempted to show that he was born at Setia in Latium. The time of his death is equally uncertain. From the somewhat vague sentence of Quinctilian "Multum in Valerio Flacco nuper amisimus," it may be inferred that he died about the year 88 A.D., while still a youth. Flaccus' only known work, the *Argonautica*, is rather imitated than translated from the Greek of Apollonius. Though it abounds in episodes and digressions, sometimes wearisome and amid which the action of the plot is altogether lost sight of, it nevertheless contains many passages of fine description and poetical sentiment; and it has been remarked that those parts of the work are best in which he disregards his original model and works out scenes and incidents of his own invention. His diction is pure, though strange words sometimes occur, and ordinary words are sometimes found with unusual meanings. The sense is likewise occasionally obscured by the useless display of erudition in which Flaccus delighted, by the frequency of remote allusion, and the employment of far-fetched and unnatural similes. Altogether, Flaccus is an author much more admired than read. He appears to have been wholly unknown to the scholars of the middle ages. His works were first brought to light by Poggio Bracciolini, who discovered a MS. copy of part of the work in 1416 in the monastery of St Gall. Of the numerous editions which have appeared since that date, the best is that of Peter Burman, Leyden, 1724. The *Argonautica* has been translated into English by Nicholas Whyte, 1565, under the title, "The story of Jason, how he gotte the golden fleece, and how he did begyle Media;" out of Laten into Englische; into Italian by Pindemonte, Verona, 1776; into German by Wunderlich, Erfurt, 1805; and into French by De Lamalle, Paris, 1811.

FLAG, an ensign or colours; a cloth on which are usually displayed certain devices, and attached to a staff. In the army, it signifies a small banner by which one regiment is distinguished from another; in the marine, a certain banner by which an admiral is distinguished from the other ships of his squadron, or by which the ships of one nation are distinguished from those of another.

In the British navy flags are either red, white, or blue, and are displayed from the top of the main-mast, fore-mast, or mizen-mast, according to the rank of the admiral. When the flag is displayed from the staff on the main-mast, the officer distinguished thereby is known to be an admiral; when from the fore-mast, a vice-admiral; and when from the mizen-mast, a rear-admiral.

The first flag in Great Britain is the royal standard, which is only displayed when the king or queen is on board the vessel; the second is that of the anchor of hope, which characterizes the lord high admiral, or lords commissioners of the admiralty; and the third is the union flag, in which the crosses of St George and St Andrew are blended together. This last is appropriated to the admiral of the fleet, who is the first naval officer under the lord high admiral.

The next flag after the union is that of the white squadron, at the main-mast head; and the last, which characterizes an admiral, is the blue, also at the main-mast head. For a vice-admiral, the first flag is red, the second white, and the third the blue, at the flag-staff on the fore-mast. The same order is observed with regard to rear-admirals, whose flags are displayed at the mizen-top-gallant-mast head. The lowest flag in our navy is accordingly the blue on the mizen-mast.

To lower or strike the Flag, in the navy, is to pull it down upon the cap, or to take it in, as a token of the respect due from all ships or fleets to those which are undeniably their superiors. To lower or strike the flag in an engagement is a sign of submission or surrender.

The method of leading a ship in triumph is to attach the flags to the shrouds, or the gallery in the hind part of the ship, letting them hang down towards the water, and to tow the vessels by the stern. Livy relates that this was the mode in which the Romans used the ships of Carthage.

To Heave out the Flag, is to display or put abroad the flag.

To Hang out the White Flag, is to ask quarter: or, when a vessel has arrived on a coast, it shows that it has no hostile intention, but comes to trade, or the like. The red flag is a sign of defiance and battle.

Flag Officers are those who command the several squadrons of a fleet; such as the admirals, vice-admirals, and rear-admirals. The flag-officers in our pay are the admiral, vice-admiral, and rear-admiral, of the white, red, and blue. See Navy, and Signals.

FLAGELLANTS, a sect of religious fanatics, one of the leading doctrines of whose creed was that by mortifying the flesh in every conceivable manner they propitiated the wrath and gained the favour of the Deity. The first recorded instances of self-flagellation are isolated cases which happened about the beginning of the fifth century of the Christian era. From this date the practice began to spread till the middle of the eleventh century, when, by the precepts and example of cardinal Peter Damian, it came to be regarded by many religious persons as a sort of duty. The custom was very warmly opposed by the more liberal minds among the clergy, but it continued to spread in despite of all opposition; and soon after the middle of the thirteenth century, the devotees of the system, no longer content to mortify themselves in private, began to do so in public, under the idea that they thus humiliated themselves more completely in the sight of God. Societies were now formed by which the doctrine of flagellation was promulgated throughout Europe; and the excesses into which they were frequently hurried by the ardour of their enthusiasm excited the astonishment even of their contemporaries. The originator and promoter of these fraternities was a monk of Perugia, Rainer by name. "About this time," says the monk of Padua in his chronicles of the year 1260, "when all Italy was filled with vice, the Perugians suddenly entered upon a course never before thought of, after them the Romans, and at length all Italy. The fear of Christ exerted upon the people so strong an influence, that men of noble and ignoble birth, old and young, traversed the streets of the city naked, yet without shame. Each carried a scourge in his hand with which he drew forth blood from his tortured body amid sighs and tears, singing at the same time penitential psalms, and entreating the compassion of the Deity. Both by day and night, and even in the coldest winters, by hundreds and thousands they wandered through cities and churches, streets and villages, with burning wax candles. Music was then silent, and the song of love echoed no more; nothing was heard but atoning lamentation. The most unfeeling could not refrain from tears; discordant parties were reconciled; usurers and robbers hastened to restore their unlawful gains; criminals before unsuspected came and confessed their crimes."

From Italy the Flagellants crossed into Germany, and visited Bavaria, Bohemia, Poland, and Alsatia, making many proselytes on the way. The princes and higher clergy, however, were little pleased with the fanatics, whose popularity lay chiefly with the lower orders. The public exposure of the person which this sect practised as a matter of duty offended good manners; their travelling in large

numbers afforded opportunities for every sort of tumult and sedition; and their extortion of alms was a severe tax upon the peaceful citizens. From the Continent they passed over into England, where they astonished the burghers of London and other cities by the severity of their discipline; but they were finally obliged to retire from Britain without having made a single convert. The purity of the early Flagellants was not long maintained by their successors; and at length, as immorality began to spread in many of the countries which they visited, they gradually fell into disfavour even with the people. At length their order was openly attacked by the celebrated Gerson; Pope Clement VII. thundered anathemas against them from the Vatican; and the officers of the Inquisition persecuted them with such severity that the sect at last disappeared altogether. An attempt made in Thuringia in 1414 by Conrad Schmidt to revive the order was suppressed by the trial and execution of that leader, and the more prominent among his followers.

FLAGEOLET, a wind-instrument of music, made of hard wood, and blown by a mouth-piece. Some flageolets are very small, and have a shrill piercing sound. Flageolets are of different sizes, and tuned to different keys, *e.g.* C, D, E flat, F, and G. There are also double-flageolets, capable of playing two parts, in which two flageolets are joined together, and sounded by the same mouth-piece.

FLAIL, an instrument for threshing corn, consisting of the hand-staff, or piece held in the thresher's hand; the swiple, or that part which strikes the corn; the caplins, strong leathern thongs which unite the hand-staff and swiple; and the middle-band, a leathern thong or fish-skin that ties the caplins together.

FLAMBEAU, a kind of torch made of thick wicks, covered with wax, and used in the streets at night, at illuminations, and in processions. Flambeaux usually consist of four wicks or branches, about an inch in thickness, and three feet long, made of coarse half-twisted hempen yarn; and these, being suspended by one end, are coated with white or yellow wax, which is poured over them from a ladle until the requisite thickness be obtained.

FLAMBOROUGH HEAD, a cape or promontory on the eastern coast of Yorkshire, five miles east of Burlington, and 215 from London. This was the *Fleamburg* of the Saxons; having, it is supposed, been so called from the lights made on it to direct the landing of Ina, who, in 547, joined his countrymen in these parts with a large reinforcement from Germany, and founded the kingdom of Northumberland. In the time of Edward the Confessor, Flamborough was one of the manors of Harold, earl of the West Saxons, afterwards king of England; but on his death the conqueror gave it to Hugh Lupus, who bestowed it on the monastery of Whitby. Remains of a Danish tower and fosse are still to be seen. The cliffs rise perpendicularly from 300 to 450 feet in height, and are composed of a rock of the chalk formation, containing numerous extensive caverns, and frequented by immense numbers of sea-fowl and wild pigeons. Many of the rocks are insulated, and of a pyramidal figure, soaring up to a vast height. The bases of most are solid, but in some instances they are pierced through and arched. In 1806 a lighthouse was erected here, having a revolving light 214 feet above the sea. N. Lat. 54. 7., E. Long. 0. 5. Flamborough is a small fishing village, with an ancient parish church, which contains a curious monumental inscription to the memory of Sir Marmaduke Constable.

FLAME. See Heat; Chemistry; Damps; Pyrotechny; Fire.

FLAMINGO. See index to Ornithology.

FLAMEN, in *Roman Antiquity*, the name of any priest consecrated to the service of some particular deity. Of the flamens the highest in point of rank were the Flamen Dialis, Flamen Martialis, and Flamen Quirinalis, who were always selected from among the patricians. When the number of flamens was raised from three to fifteen, those already mentioned were entitled *majores*, in contradistinction to the other twelve, who were called *minores*, and were chosen from the plebs. The flamens were held to be elected for life, but they might be compelled to resign office for neglect of duty, or on the occurrence of some ill-omened event during the performance of its functions. The official dress of the flamens was the *apex* or cap, surmounted with a piece of pointed olive-wood, round the base of which a lock of wool was twisted; the læna or mantle; and a laurel wreath.

The most honourable of all these priests was the Flamen Dialis, who, in virtue of his office, was entitled to a lictor, to a seat in the senate, to the toga prætexta, and to a curule chair. If a person in fetters took refuge in his house he was immediately loosed from his bonds; and if a criminal on his way to the scene of his punishment met him and threw himself at his feet he was respited for that day. To counterbalance these privileges, numerous restrictions were laid upon the Flamen Dialis. He was not allowed to leave the city for a single night; to ride or even touch a horse, a restriction which incapacitated him for the consulship; to swear an oath; to wear a ring, &c. The wife of the Dialis (who was not allowed to re-marry in the event of her death) was called Flaminica, and was obliged to assist her husband at the sacrifices and other religious duties which he performed. Some of the municipal towns in Italy had flamens as well as Rome. When it became customary to deify the emperors, flamens were appointed in all the provincial towns to superintend their worship.

FLAMINIA VIA, an ancient Roman road, constructed by C. Flaminius during his censorship, 220 B.C. Proceeding from Rome through Etruria in a direct line to Narnia, now *Narni*, in Umbria, it there divided into two branches, the one stretching eastwards through Terni and Spoleto to Foligno, where it met the other, which passed through Careoli and Bevagna. It then continued its course to Nuceria, where it again branched off in two directions, the one passing through the district of Picenum to Ancona, and along the coast of the Adriatic to Fanum Fortunæ (Fano), where it met the other, which followed the more direct line of Intercisa or Furlo, and Forum Sempronii or Fossombrone. The Via Flaminia terminated at Ariminum. (Bergier, *Hist. des Grands Chemins.*)

FLAMINIUS, C., a general of the Roman republic. The most memorable event in his history is the terrible defeat which he sustained from Hannibal at the Thrasymene Lake, B.C. 217, in which he was slain, along with the greatest part of his army. See Roman History.

Flaminius, *T. Quintius* (B.C. 230–174), an illustrious general of the Roman republic. He distinguished himself chiefly in the wars between Rome and Greece, in the course of which he gained the celebrated victory of Cynoscephalæ over the Macedonians, B.C. 197. For the details of his various campaigns in Greece, see Roman History.

FLAMSTEED, John, one of the most laborious and distinguished of British practical astronomers, and the first who obtained the appointment to the Royal Observatory, was born at Denby, near Derby, Aug. 9, 1646. He received the elements of his education at the free school of that town, where his father carried on the business of a maltster. When fourteen years of age, imprudent bathing brought on a severe rheumatism, from the effects of which his limbs never entirely recovered. This induced him, when nineteen, to visit Ireland, for the purpose of consulting a notorious quack, who professed to cure all diseases by his *touch;* but, as might have been anticipated, he soon returned no better than he went.

Even at a very early age Flamsteed showed a decided inclination for mathematical and astronomical researches. The books which seem to have awakened his mind to such

studies were Sacrobosco's treatise *De Sphæra*, which he partially translated into English, and Street's *Astronomia Carolina;* but a present afterwards made to him of Kepler's *Tabulæ Rudolphinæ*, and Riccioli's *Almagestum Novum*, with a few other tracts on astronomy, confirmed his taste for that science; and he soon began to exhibit much ingenuity in the construction of astronomical instruments.

The state of his health, and perhaps also his father's circumstances, probably prevented his proceeding to the university with some of his schoolfellows. He remained at Derby for several years, eagerly engaged in practical astronomy; and there, about 1667, gave a practical demonstration of the true principles of the equation of time; and he appears decidedly to have been the first astronomer who brought into common use the method of simultaneously observing the right ascension of the sun and stars, a mode by which the true place of any star is determinable by means of meridional altitudes and transits.

His first astronomical communication to the Royal Society was made in 1669, under an assumed anagram, which was soon detected by Oldenburg, the secretary. In the same year, in his own name, he communicated to the president, Lord Brouncker, his calculation of the solar eclipse, that had been omitted in the Ephemerides, with some other astronomical observations. This paper was submitted to a committee of the Royal Society, and obtained for its author the applause of the astronomical world.

In the following year he was invited by his father to London, and introduced to the great philosophers of the capital. He had now opportunities of seeing the best astronomical instruments then known, far surpassing those he had been accustomed to make with his own hands; and he was well received by his warm friend and admirer Sir Jonas Moore, who furnished him with several delicate instruments, among which was Townley's micrometer. In returning to Derby he visited Cambridge, and entered himself of Jesus College, where he became acquainted with Barrow and Newton, with whom he long kept up a close correspondence.

In 1672 he sedulously applied to the study of dioptrics, with the view of improving his astronomical apparatus, and continued most assiduously his celestial observations, which from time to time afforded communications to the Royal Society.

In 1673 he composed his treatise on *The True and Apparent Places of the Planets when at their Greatest and Least Distance from our Earth;* a work of which Newton availed himself in the first edition of *The Principia.* In the same year Flamsteed obtained the degree of master of arts at Cambridge.

In 1674 Flamsteed published his Ephemeris, and drew up a table of the tides, which Sir Jonas Moore presented to Charles II. and his brother the Duke of York. Flamsteed had also constructed two barometers, then uncommon instruments; which, through the same friendly hand, were presented to the royal brothers and graciously received.

Flamsteed had decided on entering the church; and, although Moore had urged his settling in another vocation in London, he persevered in his determination, and was admitted into holy orders in 1675; but he never obtained any higher preferment than the small living of Burslow in Surrey, to which he was presented by Lord Keeper North in 1684, the year in which he lost his father.

Sir Jonas had determined on establishing Flamsteed in his own private observatory at Chelsea, when the enormous errors of the astronomical tables then in use were brought under the notice of King Charles II., who determined to found an observatory. Through the good offices of Moore, Flamsteed was appointed the first "astronomical observator;" and he immediately began his celestial observations at the queen's house at Greenwich until the observatory should be finished, which it was in 1676. It was named *Flamsteed House;* and from this era Mr Baily dates the commencement of modern astronomy.

The salary was only L.100 a-year, and that not always punctually paid. Here the indefatigable Flamsteed collected the enormous mass of materials from which he furnished the first trustworthy catalogue of the fixed stars; and it was on his observations chiefly that Newton laid the foundation of his *Lunar Theory.* Yet Flamsteed was ill supported by the government. His instruments, chiefly procured at his own expense, from his scanty salary and the emoluments of his living, were very imperfect; and his requests for assistance were unheeded. The government promised much, but did nothing; though a very small portion of what was squandered during this reign on mistresses and panderers to the low pleasures of the court would have completely furnished the best observatory in Europe, and enabled this acute and indefatigable man to have still farther extended the sphere of astronomical science and the honour of his country.

His *Doctrine of the Sphere* appeared in the mathematical treatise of his friend Moore, in 1681.

Much light has been thrown on the private history of Flamsteed, and the unjust treatment he alleged he had received at the hands of some of the brightest names in the galaxy of British science, by F. Baily's discovery in 1832 of a vast mass of Flamsteed's papers and correspondence, which was published in 1835 at the expense of the admiralty. The correspondence gives Flamsteed's own version of the disputes between him and some of the most eminent philosophers of the day; and it would be unjust from such *ex parte* statements to derogate from the fair fame of a Newton or a Halley on the accusations of a man acknowledged to have been of a very irritable temper, and indignant at what he conceived to be gross injustice to himself. The defence of Sir Isaac Newton from his accusations has been partly undertaken by Dr Whewell; and the public have at length received the most complete and satisfactory vindication of this illustrious philosopher in the *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton*, by Sir David Brewster.

Flamsteed had very freely communicated his astronomical discoveries to Cassini, who had ever treated him with equal candour; and it is not denied that he had furnished Newton with every lunar observation he had made before the publication of the first edition of the *Principia*, which appeared in 1685. Flamsteed's unwillingness or refusal to contribute his observations to Sir Isaac, after their quarrel, arose from his considering himself unjustly treated by Newton and his colleagues of a committee appointed by government to examine and report on the papers of the royal astronomer. This committee consisted of Sir Isaac Newton, Sir Christopher Wren, Dr Gregory, Dr Arbuthnot, and Mr Roberts. They had, it seems, broken a seal, at the command of the sovereign, which Flamsteed had put on his imperfect catalogue of stars, on delivering it to the committee. Of this he bitterly complains. Though the report of the committee was in favour of printing Flamsteed's papers, what seems chiefly to have irritated him was, that the superintendence of printing them was not given to persons of his appointment, but confided by the committee to Dr Halley.

Flamsteed demanded back his papers, which was refused, as they were considered public property; and he commenced a law-suit for their recovery, the result of which Mr Baily could not learn; but the correspondence of Flamsteed states, that after he had spent L.200 in this suit, they were delivered up to him by Newton.

The zealous Flamsteed had expended on instruments and in completing his catalogue of stars, not only his salary, but L.2000 more, and he determined to print it. The husband of Queen Anne, on learning this, offered to print it at his own expense, and paid for the first edition; but Prince George dying in 1708, Flamsteed lost the aid of this liberal patron. During great part of the reign of Queen Anne, the astronomer royal was not on good terms with the

government, which he ascribed to the influence of Newton and Halley. On the death of the Queen in 1714, and of Newton's court patron, the Earl of Halifax, in the following year, Flamsteed asked and obtained from the treasury possession of the remaining 300 copies of Halley's publication of the first and second volumes of the *Historia Cœlestis;* a large portion of which he immediately committed to the flames, preserving only about 97 sheets of each volume, which was printed as he wished, and which he afterwards introduced into the first volume of this great work.

From 1715 to 1719 Flamsteed was earnestly employed in publishing this noble work, which he did not live to see completely printed. After his death the publication was continued by his widow, aided by Mr Crosthwaite, the observatory assistant, and Mr Abraham Sharp, a steady friend of the author. It was completed in three folio volumes in 1723. His valuable *Atlas Cœlestis* did not appear till 1753.

Of these works it is sufficient to say, that considering the period, and the then comparatively imperfect state of astronomical instruments, they are highly honourable to the author and his country, and mark an important era in the history of practical astronomy.

The first volume of the *Historia Cœlestis* contains his observations at Derby and Greenwich on the fixed stars, planets, Jupiter's satellites, comets, and spots on the sun's disk; the second contains the transits of stars and planets over the meridian, together with their places determined by such observations; the third volume contains an account of the methods and instruments used by Tycho Brahe and himself; catalogues of the fixed stars by Ptolemy, Ulugh Beigh, Tycho, the Landgrave of Hesse, and Hevelius, together with his own British catalogue of the true places of 2884 stars.

Flamsteed, though of a feeble constitution, and worn down by incessant labour, lived to his seventy-third year, when he was rather suddenly carried off by strangury on 31st December 1719. (T.S.T.)

FLANCH, or FLANGE, a projecting rim or rib on anything which serves to unite it with something else; as exemplified in the flat rims by which cast-iron pipes are frequently connected.

FLANDERS, formerly an extensive country of Europe, now forming the provinces of East and West Flanders in Belgium, part of the province of Zeeland in Holland, and the department du Nord in France. See HOLLAND, BELGIUM, FRANCE, &c.

FLANNAN ISLANDS, a group of small islands, seven in number, 12 miles N.W. of the Island of Lewis. They are wild, rocky, and uninhabited; but afford excellent pasture for sheep. From existing remains of sacred edifices, they appear to have been formerly the residence of the Culdees or some other religious order.

FLANNEL, a woollen stuff, composed of a woof and warp, and woven after the manner of baize.

Dr Black assigns as a reason why flannel and other substances of the same kind keep the body warm, that they compose a rare and spongy mass, the fibres of which touch each other so lightly that the heat moves slowly through the interstices, which being filled only with air, and that too in a stagnant state, give little assistance in conducting the heat. From the experiments of Count Rumford, it appears that there is no relation between the power which the substances usually worn as clothing have of absorbing moisture, and that of keeping the body warm. Having provided a quantity of several of these substances (as mentioned below), he exposed them, spread out upon clean china plates for the space of twenty-four hours to the warm and dry air of a room which had been heated by a German stove for several months, and during the preceding six hours he had raised the thermometer to 85° of Fahrenheit; after which he weighed equal quantities of the different substances with a very accurate balance. They were then spread out upon a china plate, and removed into a very large uninhabited room upon the second floor, where they were exposed forty-eight hours upon a table placed in the middle of the room, the air of which was at 45° of Fahrenheit. At the end of this time they were weighed, and then removed into a damp cellar, where they were placed on a table in the middle of the vault, the air of which was at the temperature of 45°, and, by the hygrometer, seemed to be fully saturated with moisture. In this situation they were suffered to remain three days and three nights, the vault being all the while hung round with wet linen cloths, to render the air as completely damp as possible. At the end of three days they were weighed, and the weights at the different times were found as in the following table:—

	Weight after being dried in the hot room.	Weight after coming out of the cold room.	Weight after remaining 72 hours in the vault.
Sheep's wool	Parts 1000	1084	1163
Beaver's fur		1072	1125
The fur of a Russian hare		1065	1115
Eider down		1067	1112
Silk ... Raw single thread		1057	1107
Silk ... Ravellings of white taffety		1054	1103
Linen.. Fine Lint		1046	1102
Linen.. Ravellings of fine linen		1044	1082
Cotton wool		1043	1089
Ravellings of silver lace		1000	1000

In regard to these experiments Count Rumford observes —that though linen, from the apparent ease with which it receives dampness from the atmosphere, seems to have a much greater attraction for water than any other, yet it would appear, from what is related above, that those bodies which receive water in its unelastic form with the greatest ease, or are most easily wet, are not those which in all cases attract the humidity of the atmosphere with the greatest avidity. "Perhaps," says he, "the apparent dampness of linen to the touch arises more from the ease with which that substance parts with the water it contains than from the quantity of water it actually holds; in the same manner as a body appears hot to the touch in consequence of its parting freely with its heat; while another body which is really at the same temperature, but which withholds its heat with great obstinacy, affects the sense of feeling much less strongly. It is well known that woollen cloths, such as flannels, &c., worn next the skin, greatly promote insensible perspiration. May not this arise principally from the strong attraction which subsists between wool and the watery vapour which is continually issuing from the human body? That it does not depend entirely on the warmth of that covering, is clear; for the same degree of warmth produced by wearing more clothing of a different kind does not produce the same effect. The perspiration of the human body being absorbed by a covering of flannel, it is immediately distributed through the whole thickness of that substance, and by that means exposed, by a very large surface, to be carried off by the atmosphere; and the loss of this watery vapour which the flannel sustains on the one side by evaporation, being immediately restored from the other, in consequence of the strong attraction between the flannel and this vapour, the pores of the skin are disencumbered, and they are continually surrounded by a dry and salubrious atmosphere."—(*Philosophical Transactions,* No. 483.)

FLAT, in *Music.* See MUSIC.

FLAVEL, JOHN, an English nonconformist divine of great learning and ability, was born at Broomsgrove in Worcestershire in 1627. He was the eldest son of Mr Richard Flavel, described in contemporary records as "a

painful and eminent minister." By this parent he was educated with the utmost care, first at home and afterwards at the grammar-schools of Broomsgrove and Haslar. Finally, he was entered of University College, Oxford, where he greatly distinguished himself in all the academical pursuits of the place. Soon after taking orders in 1650, he obtained a curacy at Deptford, and ingratiated himself so completely with the people by the earnest fervour of his eloquence in the pulpit, and the faithful discharge of his other ministerial duties, that on the death of the vicar he was unanimously appointed to succeed him. From Deptford he removed to Dartmouth, to which he had been tempted as affording a wider sphere of usefulness, though in a pecuniary point of view he suffered considerably by the change. In 1662 the Act of Uniformity was passed, and Flavel, refusing to comply with its requirements, was ejected from his living. He still continued, however, to preach and administer the sacraments privately till the Oxford Act of 1665 compelled him to retire to Slapton, five miles from the scene of his official labours, and for the next twenty years he underwent every kind of hardship and persecution in common with his nonconforming brethren till a presentiment of danger compelled James II. to abate somewhat the severity of his brother's enactments against them. After the expulsion of the Stuart dynasty, Flavel was urgently pressed to accept various calls that were offered him by metropolitan congregations; but he refused to accept any of them, and continued to labour among his parishioners of Dartmouth till his death in 1691, shortly after the union of the Independent and Presbyterian churches, an event which gave him very great joy on his death-bed. Flavel was four times married, but does not appear to have left any family behind him. His principal works are his *Treatise on the Soul of Man; The Fountain of Life, in forty-two Sermons; The Method of Grace; A Token for Mourners; Husbandry Spiritualized; Navigation Spiritualized.* It cannot be denied that these works are in their totality heavy and cumbrous in their structure; but they have received a very scant measure of justice at the hands of most English writers who have thought it worth while to notice them. They contain many isolated passages of striking merit, even in a literary point of view, and many detached thoughts of rare and daring originality. If it be true, as Johnson says, that it is the lot of Milton to be more admired than read, it is equally true that Flavel, less fortunate than his contemporary, has the misfortune to be slightingly dismissed by many persons who prove by the very character of their criticism that they have never read a line of his works. This misfortune, however, he shares with the majority of those divines who are generally classed together as the "Puritan."

FLAX, the fibre of *Linum usitatissimum*, a plant of the natural order *Linaceæ*, which is spun into thread and woven into linen textures. (See Botany, vol. v., p. 187.) The seeds yield on expression a large quantity of oil, known as linseed-oil; and the residue, called linseed-cake, is much employed to fatten cattle. Flax has been cultivated from the earliest ages in Great Britain and many other countries; but in general we have been in the habit of importing a large proportion of our supplies, particularly from Russia. The fibre of *Phormium tenax*, or New Zealand flax as it is commonly called, is said to exceed every other kind of fibre in strength, and has been imported in some quantity as a substitute for hemp in the manufacture of canvas and cordage. For the culture of flax, see Agriculture, vol. ii., p. 332, &c. (See also Spinning; Linen; Hemp.)

The quantity of flax imported into Great Britain has for a considerable number of years been gradually increasing. Twenty years ago the annual importation was about 48,000 tons; ten years since it had increased to about 65,000 tons; and at the present time it is about 80,000 tons. The proportion per cent. of this quantity imported from different countries may be judged of by the following table, calculated on the average imports of the years 1840, 1844, and 1849:—

	1840.	1844.	1849.
Russia	69·0	7·0	74·0
Prussia	11·0	10·0	10·0
Holland	9·0	8·0	6·5
Belgium	6·5	7·0	4·0
France	3 5	3·5	1·5
Other countries	1·0	1·5	4·5

During the last few years great efforts have been made to extend and improve the manufacture of this valuable fibre in various parts of the world. The increase under the last head in the preceding table, for 1849, is chiefly due to the importation of flax from Egypt. It must be remembered that, in addition to the above-mentioned quantity of flax annually imported, the manufacturers of England have consumed rather more than a quarter as much again, cultivated in various parts of the British empire, but chiefly in Ireland. This proportion has also considerably increased during the last twenty years, and a most marked improvement in the quality of the flax itself has also been effected; a change in great measure to be traced to the efforts of the Royal Society for the Promotion and Improvement of Flax in Ireland. At the thirteenth annual meeting of that society the number of acres under flax cultivation in Ireland was given as follows:—

Years.	Acres.	
1848	53,863	value L.15 per acre.
1849	60,314	...
1850	91,040	...
1851	138,619	...
1852	136,009	..
1853	175,495	...

The value of flax depends in part on the climate and soil in which it is cultivated; and in part also on the mode in which the fibre is prepared, and on the care and skill with which the process is conducted. According to its quality, its value varies from about L.40 to L.180 per ton. Another circumstance which has given a considerable impetus to the cultivation of flax is the introduction of the late R. B. Schenck's new process of steeping. Formerly the separation of the fibre from the woody matter of the stem was effected by the process of "retting," of which there were three modifications—dew-retting, pond-retting, and river-retting. The stem of the plant consists essentially of two parts;—a wooden centre or core, the shove or boon, and the external fibrous portion, which, when separated from the former, constitutes the flax. These two are cemented together by a glutinous matter, not soluble in water alone, and which must be got rid of by some means before the pure fibre can be separated from the woody shove. The old mode consisted merely in exposing the flax stems to air and moisture, under circumstances favourable to fermentation or incipient putrefaction, so that the glutinous matter being destroyed, the fibre could then be easily separated from the shove. Whether this species of fermentation is effected by exposing the flax for some weeks to the action of the dew and rain spread over meadows, whether it is effected by steeping it in ponds or pits of stagnant water, or, lastly, by sinking it in large wooden frames in the current of a deep and slow flowing river, there are serious practical difficulties which have long directed the attention of ingenious men to the possibility of discovering a less objectionable mode of preparing flax. During the slow retting of the flax, certain putrid vapours are given off in large quantity, the water and the very air itself are poisoned; and this alone is no trifling objection to the process. So serious an objection, indeed, have these putrid exhalations been found to the use of water-retting, that in some districts of Belgium, in Hainault and Namur especially, it is forbidden by law, as being dangerous to "public safety and the health of the inhabitants." In Flanders, however, no such laws are in force, and it is there commonly believed that dew-retted flax is, of necessity, meagre and dry. Many different mo-

difications and peculiar modes of retting are followed in the various flax districts of Belgium, Holland, and France; and in different localities dissimilar modes of retting have long been in use, often involving very considerable variations in principle. Thus, at Courtrai the flax crop is dried in the field, and stored for some months in barns, before it undergoes the process of retting in the river Lys. In the district of Waes it is retted immediately after being gathered, the green stems being at once thrown into pits of stagnant water. As, however, the whole operation, in every kind of water-retting, depends on the amount of fermentation produced (which must be enough to insure the decomposition of the glutinous matter, but not enough to cause any injury to the fibre), the process is necessarily slow, tedious, and very uncertain, especially towards the close of the operation, because then the flax must be most carefully watched, in order to put a stop to the fermentation as soon as the desired effect is produced. A slight change of temperature, or exposure for a few hours when the fermentation is complete, may involve the ruin of the fibre. Dew-retting is of course even slower than water-retting; depending, as it necessarily does, on the nature of the season, and being greatly retarded by long-continued dry weather.

During the last half century various attempts have been made to effect the separation of the fibrous from the woody portion of the flax stem by chemical and mechanical means. In several cases the results at first appeared to be very promising, but in every instance it was soon found that there were insuperable practical objections. Among chemical agents, solutions of sulphuric acid, caustic potash, caustic soda, quicklime, and soft soap, were all in turn tried and discarded; and among mechanical processes, the ingenious contrivances of Mr James Lee and Messrs Hill and Bundy shared the same fate. Whatever may have been the comparative merits of the two processes of these rival inventors, in the course of a few years both were relinquished and forgotten. Various other ingenious mechanical arrangements have been devised, but hitherto they have had very little success.

Schenck's process, for which he obtained a patent in 1846, is undoubtedly a very important improvement. It consists merely in steeping the flax stems in warm water, heated artificially to the temperature best suited to fermentation. In this simple way the operation is rendered rapid and certain, all uncertainty from fluctuations in the temperature and weather is avoided, and the whole process is entirely under the command of the manufacturer. The temperature best suited for this purpose is about 80°, or from 80° to nearly 90°. Above this point the process proceeds too rapidly, and the fibre is almost sure to be more or less injured. The time required is from about 70 to 90 hours. It appears to be generally admitted that the warm-water steeping increases the percentage of fibre obtained from the flax stem over that obtained by the old modes of retting by nearly one-fifth; and that, whilst the fineness and spinning qualities of the fibre are increased, the strength is in no way weakened or diminished, unless the process be permitted to proceed too far,—an accident that need never happen, from the complete control over it which the manufacturer has throughout. Although there is no doubt as to the practical value of the use of warm water in flax-retting, yet the introduction of Schenck's process is far from removing all the difficulties of the flax manufacture; much still remains to be effected, and it is by no means improbable that ere long a yet more perfect process may be devised.

It is interesting to observe, that the use of warm water in the preparation of vegetable fibre is not altogether new, it having been employed by the Malays, and by the natives of Rungpoor, in Bengal. The process adopted at Bencoolen is stated by Dr Campbell to consist in steeping the stems of the hemp in warm water, in which it is allowed to remain for two days and nights. The old German process, called "Molkenröst," sometimes used in preparing the finer sorts of flax, is also, to some extent, an application of the same principle. In this mode of retting the flax was steeped for four or five days in a warm mixture of milk and water, and thus the desired degree of fermentation in the flax stems was produced. This operation must be distinguished from the more modern one in which sour milk was used, in order to give a good colour to linen,—a process introduced by the Dutch towards the middle of last century. The linen was boiled in a weak alkaline lye, and subsequently treated with sour butter-milk, for the purpose of aiding in removing the alkali, and dissolving the earthy impurities present in the fibre. Occasionally, also, salt of sorrel was used for the same purpose; and in 1775 Reuss states that sulphuric and muriatic acids might be used for the same end; but that being too costly, they had not as yet come into general use. Of course, all processes in which boiling or even hot water is used, are quite different in their mode of action from those in which only warm water is employed. When boiling-water is used, it is with a view of dissolving and removing the useless matters which incrust the fibrous parts of the plant; whilst, on the other hand, warm water is used to soften them, and to aid in their putrefaction or decomposition through the agency of fermentation. In 1787 much interest was excited in Ireland by the publication of a plan for improving the retting of flax by the action of hot water. In this scheme it was proposed to scald the flax-stems in boiling-water to soften them, and to remove a portion of the extraneous vegetable matters which they contain; and it was conceived that after this treatment the subsequent retting of the flax would be more rapid, certain, and manageable; so that time would be saved, the noisome process of pond-retting be obviated, and the result be to yield a stronger and whiter fibre. The minute and careful experiments of Hermbstaedt on the chemical principles involved in the retting of flax (made about the beginning of the present century) threw much light on the whole subject, and to some extent indicated the influence of temperature on the success of the operation.

Flax-cotton is a material prepared from flax, hemp, and other vegetable fibres, and which very nearly resembles the fibre of the *Gossypium* or cotton-plant. M. Claussen's ingenious process for making flax-cotton (patented August 1850) consists essentially in boiling the cut and crushed stems of the flax, hemp, or other plant, in a dilute solution of caustic soda, containing about $\frac{1}{2000}$th part of alkali. The fibrous matter is then removed, and plunged into a bath of dilute sulphuric acid, containing $\frac{1}{500}$th part of acid, in which it is boiled for about an hour. It is next transferred into a solution containing about ten per cent. of carbonate of soda; and, lastly, when it has remained in the latter for an hour, it is plunged into a weak solution of sulphuric acid, consisting of one part of acid to 200 or 500 parts of water; in this it is left for about half an hour, and the process is completed. The effect of these several processes is "to divide and split up" the fibre in a most remarkable manner, so as completely to alter its character. Flax thus treated is converted into a substance very nearly resembling cotton. It is probable that flax-cotton can be advantageously used in the manufacture of mixed fabrics, as it appears capable of being spun with wool, silk, and other fibres; it may, therefore, perhaps hereafter lead to several new and important practical applications.

The idea of modifying the fibre of flax and hemp, so as to convert it into a kind of cotton, is by no means new. In 1747 Lilljikreuzes and Palmquist described a mode of converting flax into "cotton," by boiling it for some time in a solution of caustic potash, and subsequently washing it with soap. In 1775 considerable quantities of refuse flax and hemp were converted into "flax-cotton" by Lady

Flaxman.

Moira, with the aid of T. B. Bailey, of Hope, near Manchester. The full details of the process employed do not appear to have been published; but from Lady Moira's letters in the *Transactions of the Society of Arts* for 1775, it appears that the fibre was boiled in an alkaline lye, or a solution of kelp, containing carbonate of soda, and subsequently scoured. The result of this was that "the fibres seem to be set at liberty from each other," after which it may be "carded on cotton cards." It appears that at this time flax-cotton "was made and sold at 3d. a pound;" and Lady Moira states, that she believes that it takes colours better than flax. It is curious to observe the fate of Lady Moira's scheme: she says,—"I have no reason to be vain of the samples I have sent you; they merely show that the material of flax-cotton, in able hands, will bear manufacturing, though it is my ill fortune to have it discredited by the artizans who work for me. I had, in Dublin, with great difficulty, a gown wove, and three waistcoats; but had not the person who employed a weaver for me particularly wished to oblige me, I could not have got it accomplished."

Subsequently to this, several attempts were made in Germany to convert flax into a fibre resembling cotton. In 1777, Baron Meidinger proposed to convert flax into a sort of cotton, by the action of alkaline solutions, &c. In 1780 a factory was established at Berchtoldsdorf, near Vienna, for the practical working of this process; and similar plans were subsequently brought forward by Kreutzer in 1801, Stadler and Haupfner in 1811, by Sokou in 1816, and by several others. At the factory at Berchtoldsdorf, not only was flax converted into cotton, but likewise a useful cotton-like fibre was prepared from tow and refuse flax; and the same is said to have been done by Haag, near Pressburg, in 1788, by Göbell in 1803, and Segalla in 1811. Whether these various plans failed from the effects of jealousy and opposition, like that which prevented Lady Moira from introducing her "flax-cotton," is unknown, but it does not appear that any of them were long persevered in: it is probable, that in most cases the neighbouring manufacturers set themselves against the introduction of flax-cotton: for Beckmann, who speaks of its manufacture near Brunswick, states that the work-people determined not to use the new material, though at the same time he observes, that excellent fustians were made which could not be distinguished from those manufactured with ordinary cotton. The extreme similarity of flax-cotton to ordinary cotton is also remarked by Des Charmes (1799), who states, that if the staple be cut before it is carded, it is not possible to distinguish it from cotton, either in its raw state, or when manufactured. The matter was subsequently investigated by Berthollet, by Gay Lussac, and by Giobert, who employed alternately steepings in hot solutions of soap, alkali, and sulphuric or muriatic acid. Berthollet observes, that equally fine cotton is obtained from the commonest refuse tow as from the best flax.

For some valuable information on fibrous materials, the produce of India, which may be cheaply and usefully substituted for Russian hemp and flax, see "The Fibrous Plants of India fitted for Cordage, Clothing, and Paper," by J. Forbes Royle, M.D., F.R.S., Lond. 1855; and also an article, entitled "Indian Substitutes for Russian Produce" in the *Edinburgh Review* for July 1855.

FLAXMAN, John, an eminent English sculptor, born at York July 6, 1755, was the second son of John Flaxman, a moulder in plaster, who kept a shop in London for the sale of his figures. He was of a weakly constitution, and slightly deformed, which prevented him from mingling in the robust pastimes of youth; but he was not idle. Behind his father's counter, with drawing materials before him, he busily employed himself in transferring to paper representations of the numerous figures with which he was surrounded. But he did not confine himself to copying alone. Young as he was, he had dipped into the Iliad, and actually attempted to design historical illustrations of that immortal epic. His education seems to have devolved principally upon his parents; and as his thirst for knowledge was great, the superintendence of his studies must have been an easy task. At his books and models he laboured incessantly, and before he entered his tenth year he had made a great number of small models in plaster of Paris, wax, and clay, some of which are still preserved; and, besides being interesting as the first efforts of genius, they possess considerable merit as works of art. At ten years of age a salutary change took place in his health; he became strong, lively, and active; and the crutches by means of which he had hitherto walked were thrown aside. With renovated health he came to the determination to follow sculpture as a profession. In his father's shop, where he assiduously pursued his studies, he learned form and proportion from the casts of antique statues which it contained; whilst in the woods and fields he was supplied with new images and ideas of beauty. At the house of a Mrs Mathew, whose husband had been attracted to the youthful sculptor, Flaxman often spent his evenings hearing her read Homer and Virgil, and discourse upon sculpture and poetry. By this lady he was encouraged to study the dead languages; and although he never attained to great scholarship, he obtained such a knowledge of Greek as enabled him to embody the ideas of the ancient poets in a manner which no modern artist has surpassed. He embodied those passages which caught his fancy whilst he sat listening to Mrs Mathew; and the taste displayed in these juvenile efforts induced a gentleman to order six large drawings in chalk, the subjects being chosen from antiquity. The praise bestowed upon these gave new impulse to his genius, and strengthened that consciousness of superior power which he early experienced; yet he never overrated himself, nor allowed his industry to relax on account of the flatteries of friends, but continued to labour assiduously, well knowing that it was only in this manner that great eminence was to be attained in art.

In his fifteenth year Flaxman became a student of the Royal Academy, and soon made himself known by assiduous and enthusiastic application. In the same year he carried off the silver medal; and in due time became a candidate for the gold one, but was unsuccessful. This defeat, however, only increased his assiduity; but finding himself now compelled to labour for bread, he employed himself with the Wedgewoods, the enterprizing potters, to make designs for adorning their wares. His sketches consisted chiefly of small groups in very low relief, the subjects being taken from ancient poetry and history. Previously to this period the porcelain of England had little external beauty to recommend it; and the genius of Flaxman may be said to have created this branch of art in his native country. In 1782 he quitted the paternal roof, and married Miss Ann Denman, a lady of many virtues and accomplishments, in whose society he enjoyed much domestic happiness. During the ten years which preceded this event he had exhibited some thirteen works at the Royal Academy, but, from the pecuniary difficulties under which he laboured, none of these were executed in marble. Shortly after his marriage he formed the resolution of studying at Rome; and at the end of five years of incessant labour, during which he executed several monuments and other works of considerable merit, he was enabled to carry his design into execution. In Rome he executed a number of works. For three individuals of his own country he illustrated Homer, Æschylus, and Dante. These designs are splendid, being varied with great skill, and drawn with a fine sense of the beautiful and harmonious in composition. Of works in marble he executed a small-size group of Cephalus and Aurora; a statue of Lord Mansfield; a group representing

the fury of Athamas, from Ovid's *Metamorphoses*, consisting of four figures of the heroic size; and the restoration of that splendid torso which is generally believed to be a fragment of a Hercules. This last undertaking was as difficult as it turned out to be thankless. He not only completed the figure of Hercules, but added another of Omphale. But this statue did not give satisfaction to the connoisseurs of Italy, and Flaxman caused it to be destroyed some time previously to his death, without any injury to his fame. The remains of ancient sculpture in Rome, and in other cities of Italy, engaged not a little of his attention. He executed numerous drawings, and made a great many memoranda, the most valuable of which were subsequently embodied in his lectures on sculpture. He had been elected a member of the academies of Florence and Carrara; and after seven years' residence abroad, he at length returned home.

Flaxman's statue of Lord Mansfield had raised the expectations of his countrymen to a high pitch. In 1797 he was elected associate of the Royal Academy, during which year he sent to the exhibition three sketches in bas-relief from the New Testament, and a monument to Sir William Jones. The sketches are distinguished for their elegance of grouping. The monument is a bas-relief, but not one of the artist's most fortunate efforts in that line. In the forty-fifth year of his age Flaxman was elected a member of the Royal Academy, and, as is usual on such occasions, presented to the institution a work of art. His offering on this occasion was a marble group of Apollo and Marpessa; the conception of which is fine, though the workmanship is not so good. In the mechanical use of the chisel he never excelled. It was now his ambition to be employed upon some great national work, and he proposed to make a statue of Britannia two hundred feet in height, but the project was not carried into execution. His fame, however, was now firmly established, and commissions flowed rapidly in. A quick succession of noble works followed from his hand, one of which, a monument in memory of the family of Sir Francis Baring, is considered among the greatest efforts of his genius. One of his biographers remarks with respect to it, "This is one of the finest pieces of motionless poetry in the land." Of historical monuments Flaxman executed several, but they are not equal to his other works. They have been admired for the fine sentiment which pervades them, but their execution is considered by many as coarse and heavy. The statue of Sir Joshua Reynolds is one of his best productions. But the works he loved most were those which embodied poetical passages in the Bible; and of these he executed a great number. In 1810 the Royal Academy created a professorship of sculpture, and bestowed it upon Flaxman. His lectures are ten in number. The style is rather heavy; yet although his compositions are destitute of those flashes of poetry which irradiate the pages of Fuseli, they display a very comprehensive knowledge of the subject, much sound sense, and are more calculated to convey definite information to the student than those of the other artist above named. But if the offspring of his pen was cold and uninformed with ideal beauty, the productions of his pencil and chisel display an exuberance of imagination. His sketches and drawings are very numerous. Amongst the works which he illustrated were the Pilgrim's Progress, Sotheby's translation of Oberon, and Hesiod. These designs are in all respects fully equal to his other works, and unsurpassed by anything which ever was executed in that line. During the last ten years of his life Flaxman produced some of his noblest works. Amongst these were the group of the Archangel Michael vanquishing Satan, the Shield of Achilles, Psyche, the Pastoral Apollo, and the statues of Michael Angelo and Raffaelle. The first is a work of the highest merit, and worthy of the great poem which it illustrates. "In the Psyche and the Pastoral Apollo," says Mr Allan Cunningham, "the genius of him who illustrated Homer is sufficiently apparent; a certain austere composure is breathed over them. The Michael Angelo and the Raphael are poetic, yet real; heroic, yet familiar; and their costume, though not antique, is at once historic and picturesque." Flaxman's statues of Burns and Kemble, executed about the same time, are scarcely so happy. Amongst his other works were monuments to Collins at Chichester, and to Earl Howe in St Paul's; and statues of Washington, Nelson, Pitt, and Sir John Moore. They are of various excellence, yet all more or less bear the impress of genius and taste. But the career of this great sculptor was drawing to a close. In the beginning of December 1826 he was seized with an inflammation of the lungs, which terminated fatally on the 7th of the same month.

In stature Flaxman was small, and his figure was slim. In manners he was mild, gentle, and placable; and his mind, whilst it was rich in the gifts of genius, was embued with unaffected piety. Of his works there are four kinds; the religious, the poetic, the classic, and the historical. In each of these he has left specimens which entitle him to rank very high as an artist, but in all he has not attained the same degree of excellence. In the historical and the classic he was less successful; but in the religious and poetic he has been surpassed by no modern sculptor in purity, simplicity, and taste. His religious compositions consist of groups and figures embodying moral and spiritual passages from Scripture. They are generally of small dimensions, but very numerous. His mind was essentially poetical; and his productions are embued with the finest inspiration. It was probably of some of these works that Sir Thomas Lawrence spoke when he said of Flaxman, "His solitude was made enjoyment to him by a fancy teeming with images of tenderness, purity, or grandeur. His genius, in the strictest sense of the words, was original and inventive." His lectures were published in 1829, in one vol. 8vo, illustrated with fifty-two plates. (J. F. S.)

FLEAM, in *Farriery*, the name given to several kinds of instruments used to open veins for letting blood.

FLECHE, La, a town of France, department of Sarthe, and capital of a cognominal arrondissement, stands in a pleasant valley on the right bank of the Loir, 24 miles S.S.W. of Mans. The streets are wide and clean, and ornamented with fountains. It is chiefly noted for its royal military college, formerly a celebrated Jesuit's college, founded by Henri IV. in 1603, and which numbered among its students Descartes, Mersenne, and Prince Eugene. Among other public buildings are the Church of St Thomas, with a spire (*flèche*), from which the town takes its name, the town-hall, court-house, and hospital. The vicinity is fertile and well cultivated. Pop. (1851) 6543.

FLÉCHIER, Esprit, bishop of Nismes, one of the most celebrated preachers of his age, and author of a number of works, was born at Pernes, a small town in the diocese of Carpentras, on the 10th of June 1632, and educated under the eye of his uncle, Father Audifret, general of the Congregation of Christian Doctrine, a learned and estimable man. According to the constitution of the congregation, Fléchier, having completed his own education, was immediately employed in teaching. In 1659, when only twenty-seven, he professed rhetoric at Narbonne, and there pronounced the funeral oration of M. de Rebé, archbishop of that city. A few months afterwards, on the death of Audifret, Fléchier laid aside the habit of the *Doctrinaire*, and proceeded to Paris, where he was at first employed in the humble occupation of a parochial catechist; but he soon made himself known by his Latin and French poetry, and particularly by a description in Latin verse of the brilliant carousal, *Circus Regius*, given by Louis XIV. in 1602. This was the commencement of Fléchier's reputation. He

Fléchier. was now entrusted with the education of Louis Urbain Lefevre de Caumartin, afterwards intendant of finances and counsellor of state; and as the house of his pupil's father was then frequented by the most considerable personages both of the court and the city, Fléchier was introduced into the first society, and soon made many friends for himself by his virtues and talents. The Duke of Montausier declared himself his patron, and procured him the place of reader to the Dauphin. The sermons of Fléchier increased his reputation, which was afterwards raised to the highest pitch by his funeral orations. Having been chosen to pronounce that of Madame de Montausier, he displayed so great talent on the occasion, that his discourse opened to him the doors of the French Academy, into which he was received in 1673, in the room of M. Godeau, bishop of Venice. The favours of the court now flowed upon Fléchier. The king gave him successively the abbey of St Leverin, in the diocese of Poitiers, the office of almoner to the dauphiness, and, in 1685, the bishopric of Lavaur, accompanying his kindness with the most flattering expressions of favour and regard. "I have made you wait a little for a place which you have long merited," said the monarch; "but I did not wish to deprive myself sooner of the pleasure of hearing you." From the see of Lavaur Fléchier was, in 1687, translated to that of Nismes, which was more valuable, and also accounted more honourable. His own wish was to remain at Lavaur; but the king overcame his repugnance to the proposed translation by making him sensible that he would be more useful to the church at Nismes than at Lavaur, and that in the former place there was more labour to be performed and more good to be done. In fact the Calvinists were very numerous at Nismes; and although several had made abjuration, their conversion was at best but equivocal. But Fléchier, by his prudent conduct, in which zeal was tempered by charity, brought back the greater number of these sectaries to the bosom of the church, and made himself esteemed and beloved even by those who declined to abjure their faith. During the troubles in the Cévennes he softened, as much as in him lay, the rigour of the edicts, and showed himself so sensible of the evils of persecution, and so indulgent even to what he regarded as error, that his memory was long held in veneration amongst the Protestants of that district. In the famine which succeeded the winter of 1709, he did much to alleviate the prevalent distress, by assisting the poor in his diocese without regard to their religious tenets; alleging that all alike were his children. He also published an eloquent pastoral letter on the subject of a cross of St Gervais, which, it was pretended, worked miracles, and warned his flock against those lying wonders by which the credulity of the people has frequently been abused. This appears to have been amongst his last efforts in the cause of truth and religion. He died at Montpellier on the 16th February 1710, at the advanced age of seventy-eight. "He died," says D'Alembert, "lamented by the Catholics, regretted by the Protestants, and having always exhibited to his brethren an admirable model of zeal and charity, simplicity, and eloquence."

Fléchier's works are, 1. *Antonii Mariæ Gratiani de Vita Joannis Francisci Commendoni Cardinalis*, libri iv., Paris, 1699, in 12mo; 2. *La Vie du Cardinal Commendon*, Paris, 1671, in 4to; 3. *De Casibus Virorum Illustrium autore Antonio Maria Gratiano, opera et studio Sp. Flecherii*, Paris, 1680, in 4to; 4. *Histoire de Théodose-le-Grand*, Paris, 1679, in 4to, composed for the education of the dauphin; 5. *Histoire du Cardinal Ximenes*, Paris, 1693, in 4to; 6. *Oraisons Funèbres*, 1681, in 4to and in 12mo; 7. *Panégyriques des Saints*, Paris, 1690, in 4to; 8. *Sermons de Morale prêchés devant le Roi, avec des Discours synodaux et les Sermons prêchés par Fléchier aux Etats de Languedoc et dans sa Cathédrale*, in 3 vols. 12mo; 9. *Œuvres Posthumes contenant ses Harangues, Compliments, Discours, Poésies Latines, Poésies Françaises*, Paris, 1712, in 12mo; 10. *Mandements et Lettres pastorales, avec son Oraison Funèbre par l'Abbe du Jarry*, Paris, 1712, in 12mo; 11. *Lettres Choisies sur divers sujets*, Paris, 1715, in 2 vols. 12mo; 12. *Relation d'un Voyage en Auvergne*. The only collection yet published of the works of Fléchier is that of the Abbé Ducreux, canon of Auxerre, which appeared under the title of *Œuvres Complètes de Messire Esprit Fléchier*, Nismes, 1782, in 10 vols. 8vo. If we except the History of Theodosius, pulpit eloquence is the only branch of the belles-lettres cultivated by Fléchier in which he excelled. His Funeral Orations have been compared with those of Bossuet, without attending to this distinction, that comparisons become useless between two kinds of genius which are totally different. That of Bossuet was sublime throughout. Fléchier, on the other hand, was only remarkable for the nobleness of his thoughts and the harmony of his diction. It is true that he possessed in an eminent degree these two qualities of an orator, and that nobody has carried the latter further than he; but even in that department where he has been most successful Fléchier is not without faults, and may be reproached with an ambition of giving point to his thoughts, an affectation of symmetry in the style, and a love of antitheses, all at variance with the principles of good taste. But if his funeral orations and sermons lose much of their merit by a too measured elegance, his pastoral instructions and synodal discourses are wholly free from such affectation, indeed as remarkable for simplicity of style as for generosity of sentiment, and that indulgent spirit which laments whilst it combats error, and which, repudiating all attempts at persecution, seeks to win men over to the right way, not by the instrumentality of fear, but through the medium of their understanding and affections. "C'est dans ces ouvrages," says a distinguished French critic, "que la philosophie elle-même apprendra l'usage qu'on doit faire des luminères et du sentiment, et se convaincra que l'humanité n'a pas de consolation plus solide que la religion, comme la politique n'a pas de meilleur appui." (J. B—E.)

Flecknoe || Fleet.

FLECKNOE, Richard, a poet and dramatic writer in the reign of Charles II. He was an Irishman by birth, and was originally a priest of the Order of Jesus. Like many of the small wits and minor poets of that day, Flecknoe owes the rescue of his name from oblivion to the satirical genius of Dryden. That satirist availed himself of Flecknoe's name as a stalking horse from behind which to assail the poetaster Shadwell, who had been appointed to replace him in the laureateship. The opening lines of this satire may be quoted as a specimen of the whole:—

All human things are subject to decay;
And when fate summons, monarchs must obey.
This Flecknoe found, who, like Augustus, young
Was called to empire, and had governed long;
In prose and verse was owned without dispute
Throughout the realms of nonsense absolute, &c. &c.

It is but fair, however, to remark, that clever and effective as this poem is, it is in its application to Flecknoe utterly unjust. Flecknoe was the author of several plays, one of which was acted with considerable success, and also of many minor pieces, which, though possessing no great merit in the matter of versification, nevertheless contain many happy turns of thought and felicities of expression. His most important works were the following:—

Les Demoiselles à la Mode, printed in 1677, and addressed to the Duke and Duchess of Newcastle; *Ermina, or the Chaste Lady*; *Love's Dominion*, printed in 1654; and *The Marriage of Oceanus and Britannia*. His other works consist of, 1. *Epigrams and Enigmatical Characters*, 1670, in 8vo; 2. *Miscellanea*, or Poems of *all* sorts, with divers *other* pieces, 1653, in 12mo; 3. *Diarium*, or the Journal, divided into twelve Jornadas, in burlesque verse, London, 1656, in 12mo. Flecknoe died in 1678.

FLEECE, the covering of wool shorn from a sheep. See Wool.

FLEECE, Order of the Golden, one of the most eminent orders of knighthood in Europe, was founded in 1430 by Philip III. duke of Burgundy. By its foundation his successors were declared hereditary grand-masters; and thus the title passed to the imperial house of Austria with the Burgundian inheritance, and thence to the Spanish line of the same house after the death of the emperor Charles V. When the Spanish Netherlands, however, became Austrian, and the Bourbons became monarchs of Spain, the grandmastership was claimed by the archdukes of Austria. Hence at present the Spanish and the Austrian sovereigns alike confer the order, and at both courts it gives the highest rank.

FLEET, a navy or a squadron of ships of war; or a num-

ber of ships in company, whether ships of war or of commerce.

FLEET PRISON. See LONDON.

FLEETWOOD, a rising seaport and watering-place in Lancashire, at the mouth of the Wyre, and connected with Preston by a railway 22 miles in length. Fleetwood dates its rise from 1836, and takes its name from Sir P. H. Fleetwood by whom it was laid out, and who has erected various public buildings. It has a neat church, several chapels and schools, mechanics' institute, subscription news-room, market-house, lighthouse, docks, two wharfs, custom-house, and bonded warehouses. Steamers ply between it and Glasgow, Belfast, Londonderry, and Isle of Man. The number of vessels registered at the port on 31st December 1853 was 30 sailing vessels of 3804 tons, and 5 steamers of 904 tons; during that year 443 sailing vessels of 33,874 tons, and 672 steamers of 117,880, entered; and 268 sailing vessels of 19,255 tons, and 671 steamers of 118,725 tons left the port. Pop. (1851) 3048.

FLEETWOOD, CHARLES, lord-deputy of Ireland under the Commonwealth, and son-in-law of Cromwell, was one of the most prominent of the minor figures in that troubled period of English history. Entering the ranks of the parliamentary forces, he rose in 1644 to the rank of colonel of horse, and was appointed governor of Bristol in that same year. In the course of the civil wars that afterwards distracted the kingdom he distinguished himself, particularly at the battle of Worcester, and by his conduct on that occasion gained the favour of Cromwell and the whole army. After the death of his first wife he was pitched upon by Cromwell as a fitting husband for his eldest daughter Bridget, the widow of Ireton, and was appointed commander-in-chief of the forces in Ireland. Though the Protector did not place very much confidence in Fleetwood's attachment to himself, political motives afterwards induced him to nominate him one of the fourteen major-generals to whom the internal administration of the commonwealth was intrusted. On the death of the Lord Protector, Fleetwood did his best, by means of his influence with the troops, to supplant Richard Cromwell; but in the midst of his intrigues the nation recalled the exiled Stuarts. Fleetwood's prominent position marked him out as an object of vengeance to the restored king, and it was only with very great difficulty that he escaped with his life. Not long after the Restoration he died in wretchedness and obscurity at Stoke Newington, whither he had retired.

FLEETWOOD, *William*, a learned English bishop, descended of an ancient family in Lancashire, was born in the Tower of London, Jan. 21, 1656. He received his education at Eton, and at King's College, Cambridge. About the time of the Revolution he entered into holy orders, and having soon become a distinguished preacher, was appointed chaplain to King William and Queen Mary. By the interest of Dr Godolphin, vice-provost of Eton and residentiary of St Paul's, he was appointed rector of St Austin's, London, which is in the gift of the dean and chapter of St Paul's; and soon afterwards he also obtained the lectureship of St Dunstan's in the West. In 1691 he published his *Inscriptionum Antiquarum Sylloge*, in two parts; one containing remarkable pagan inscriptions, the other part ancient Christian monuments. In 1692 he published a translation of Jurieu's *Plain Method of Christian Devotion*, the twenty-seventh edition of which was printed in 1750. In 1701 appeared his *Essay on Miracles*, which called forth the animadversions of several writers, particularly Hoadly. In 1704 he published anonymously *The Reasonable Communicant*; and in 1705, *Sixteen Practical Discourses* on the relative duties of parents and children, husbands and wives, masters and servants, with three sermons on the case of self-murder. In the following year he was nominated to the see of St Asaph. In 1710 he published a vindication of the thirteenth chapter to the Romans, upon the authority of which the regal dignity had been so magnified by some as to make tyranny seem an ordinance of God, and to represent the most abject slavery as founded upon the principles of religion. This degrading doctrine was highly offensive to Bishop Fleetwood, who in this tract contends that, in the chapter referred to, St Paul requires of no people any more submission to the higher powers than that which is enjoined by the laws of their several countries. In 1712 he published Four Sermons, one on the death of Queen Mary in 1694, another on that of the Duke of Gloucester in 1700, a third on that of King William in 1701, and a fourth on the accession of Queen Anne; and also, the same year, an anonymous tract on Lay Baptism, according to the Church of England, a subject which then engaged a good deal of attention. *The Life and Miracles of St Wenefrede*, together with her Litanies, appeared in 1713, likewise without his name; the object of which was to expose the absurd superstitions by which weak minds are apt to be influenced, and, in particular, to show the delusions which had been practised under the names of pretended saints. In 1714 he was translated from the see of St Asaph to that of Ely, and continued there till his death, which took place at Tottenham, Middlesex, on the 4th of August 1723.

The remaining works of Bishop Fleetwood are these:—1. The Chancellor's Plea in the Divorce of Sir G. Downing, 1715; 2. Papists Not Excluded from the Throne on Account of Religion, 1717; 3. A Letter from Mr T. Burdett, Executed at Tyburn for the Murder of Captain Falkner, to some Attorneys' clerks of his acquaintance, 1717; 4. A Letter to an Inhabitant of the Parish of St Andrews, Holborn, about New Ceremonies in the Church, 1717; and 5. A Defence of Praying Before Sermon, as directed by the fifty-fifth canon. All these tracts, however, were published without the author's name. Bishop Fleetwood's character stood deservedly high in general estimation. His virtue was without any alloy of fanaticism, and his piety wholly untinctured with superstition. He was the friend of liberty and learning, equally zealous in defending the one and in encouraging the other. He assisted Dr Hickes in his great work *Linguarum veterum Septentrionalium Thesaurus*; and Hearne also confesses himself to have been under many obligations to him. In a professional point of view, he was unquestionably the best preacher of his time; and his occasional sermons exhibit a felicity of adaptation to the circumstances that had called them forth, which we should perhaps seek for in vain in similar compositions of that period. (J. B—E.)

FLEMISH LANGUAGE, that which is otherwise called *Low Dutch*, to distinguish it from the *German*, of which it is a corruption and a kind of dialect. It differs from the *Walloon*, which is a corruption of the French language.

FLEMISH SCHOOL. See PAINTING; and ARTS, § *Fine Arts*.

FLENSBORG, a seaport-town of Denmark, duchy of Sleswick, at the head of a fiord, about 16 miles from its mouth in the Baltic, and 20 N. by W. of Sleswick. Next to Copenhagen it is the most important commercial town in the Danish dominions. It has a number of vessels engaged in the West India trade and in the Greenland whale fishery: shipbuilding, with its collateral branches of industry, is carried on to a considerable extent; and there are extensive sugar-refineries, distilleries, soap-works, paper-mills, &c. It has one German and three Danish churches, three market-houses, a school of navigation, midwifery school, exchange, theatre, and public library. The churchyard is interesting as containing the remains of the Danish soldiers who fell in the battle of Istedt (25th July 1850). The government has placed a marble headstone at each grave—officers and common soldiers—with the same simple inscription on each, viz., after the name and rank, "fell at Idstedt." A railway has recently been opened connecting this town with Tonning. Pop. (including suburbs) about 18,000.

FLESH, a compound substance, consisting of the various softer solids of the animal body, and so denominated in contradistinction to bone. It consists chiefly of fibrin, with albumen, gelatine, extractive, phosphate of soda, phosphate

of ammonia, phosphate and carbonate of lime, and sulphate of potash. The general term flesh includes the muscles, fat, glands, &c., though sometimes it is restricted to muscle. See ANATOMY.

FLETA, an excellent Latin treatise on the entire body of the English law, by an anonymous author who lived in the time of Edward I., and wrote it during his confinement in the Fleet prison (hence Fleta).

FLETCHER, ANDREW, of Saltoun, a conspicuous political and social figure in Scotland during the latter half of the seventeenth century, was born in 1653 at Saltoun, in East Lothian, memorable also as the birth-place of Dunbar, the greatest of the old Scottish poets. The minister of the parish to whose care the education of the young Fletcher was intrusted was Gilbert Burnet, afterwards the celebrated bishop of Salisbury. It is not unlikely that from this preceptor Fletcher's mind received that political direction which he pursued in after life with such undeviating consistency. He certainly acquired, under Burnet's care, that knowledge of the Greek and Roman classics which afterwards supplied him with precedents for those political ideas which it was the main object of his life to realize in his native land. On reaching manhood Fletcher visited the Continent and spent several years in examining the laws and institutions of the leading European states. He then returned home, and in 1681 took his seat in the Scottish parliament as commissioner for the shire of East Lothian, and distinguished himself by the bitter and inflexible spirit in which he opposed the tyrannical tendencies of Charles the Second's government. Soon after he found it necessary to retire to Holland, at that time the general resort of all British political malcontents. In consequence of this step he was outlawed and his estate was confiscated. In 1683 he ventured over to England; but not being able to effect anything at that time, returned to the Continent, where he waited for two years till the Duke of Monmouth had completed his arrangements for a descent upon England. In this expedition Fletcher took part, but shortly after the landing at Lyme in Dorsetshire he had the misfortune to kill the mayor of that town in a quarrel, and was obliged in consequence once more to seek safety abroad. He fled to Spain; was there thrown into prison, from which he escaped in a manner (according to the traditionary accounts) savouring somewhat of the miraculous; and after a long pedestrian tour through that country passed into Hungary, where he joined the army as a volunteer, and distinguished himself by his daring and military capacity in the Turkish campaigns. On returning to the Hague he took an active part in forwarding the scheme of the English Revolution; and in 1688 returned to his native country. He immediately regained possession of his estate, and sat as a member, first in the Scottish Convention, and afterwards in the parliament. His intractable temper, and the jealousy with which he watched over the interests of Scotland, soon led him to oppose the government of William as stoutly and vehemently as he used to denounce and resist the encroachments of that monarch's two immediate predecessors. To the very last he held out against the Union of the two kingdoms; and when, very much to his chagrin, that measure was effected, he proposed in one of his works twelve *Limitations*, which he was strongly of opinion should be observed in the political relations of England and Scotland. Failing to secure the adoption of these, he retired from public life altogether, under the melancholy idea that he had survived not only his country's glory but her very existence as an independent nation. He died at London in 1716.

In a contemporary record, prefixed to one of the editions of his works, Fletcher is described as a "low thin man, of a brown complexion, with a stern, sour look, and fifty years old." The stern earnestness of his republicanism, according to this same writer, "made him oppose King Charles, invade King James, and oppose the giving so much power to King William, whom he never would serve; nor does he ever come into the administration of this Queen, but stands up a stout pillar for the constitution of the parliament of Scotland." On religious topics, however, it seems that his views were somewhat more liberal; for it is added, "His thoughts are large as to religion, and could never be brought within the bonds of any particular sect." His temper was so untractable as on many occasions to lead him to excesses utterly unwarrantable. One of the most notable instances of this was his murder of the mayor of Lyme, who merely attempted to remonstrate, when Fletcher, without asking leave, took possession of a horse belonging to that official, when he rode into Monmouth's camp with a view to aiding that adventurer in his attempt on the English crown. Less disastrous in its consequences, but equally characteristic, was Fletcher's conduct to Lord Stair, when he collared that nobleman, and threatened him with personal violence in the parliament house merely for letting drop a few words which Fletcher believed to reflect on him. To his political creed he adhered with unyielding consistency till his death, and, according to the testimony of Lockhart of Carnwath, "was so exceedingly wedded to his own opinions that there were few (and those, too, must be his beloved friends, and of whom he had a good opinion) he could endure to reason against him, and did for the most part so closely and unalterably adhere to what he advanced, which was frequently very singular, that he'd break with his party before he'd alter the least jot of his scheme and maxims." It is hard to decide whether his hatred of monarchical governments, or of England and the Union, was the most intense. Lockhart, however, believes that his aversion to the latter was so great that "in revenge to them he'd have sided with the royal family." He was, however, both by birth and temper, completely aristocratic in his tendencies, and it is said "liked, commended, and conversed with high-flying Tories more than any other set of men, acknowledging them to be the best countrymen and of most honour and integrity." Still, however, the general character both of his writings and of his political career was such as to entitle him to a high place among the advocates of British democracy. His personal character is absolutely free from every taint of meanness or dishonesty. In the words of Lockhart, "he hated and despised whatever was mean or unbecoming a gentleman, and was so steadfast to what he thought right that no hazard or advantage—not the universal empire nor the gold of America—could tempt him to yield or desert it."

Fletcher was a man of very considerable accomplishments. He was a complete master of the Latin, Greek, Italian, French, and Spanish tongues, and was well versed in history and civil law. His writings also in point of literary quality reach a high, sometimes even a remarkable, degree of excellence. The sagacity of his remarks, the freshness, energy, and occasional eloquence of his style, and the singular felicity of many isolated expressions, give a charm to his writings which compensates in a certain measure for the narrowness of view and illiberal bigotry with which they have been often charged. The most important of his works are —*A Discourse of Government with relation to Militias*, Edin., 1698; *Two Discourses concerning the affairs of Scotland*, Edin., 1698; *Discorso delle Cose di Spagna*, Napoli, 1698; *Speeches by a Member of the Parliament* which began at Edinburgh the 6th of May 1703, Edin., 1703; *An Account of a Conversation concerning a right regulation of Governments for the common good of Mankind*, Edin., 1704. In the last of these works, in which the interlocutors are Sir Edward Seymour, Sir Charles Musgrave, the Earl of Cromarty, and Fletcher himself, occurs for the first time in English literature the oft-quoted remark of the superiority of the national ballad-maker to the

national legislator. In the discourse on the affairs of Scotland a singular proposal is found, to the effect that the poor ought to be provided for by the resuscitation of a scheme of slavery such as the author believed to subsist among the ancient Greeks and Romans. The life of Fletcher was written in the style rather of a panegyrist than of a critical biographer by the late Earl of Buchan. His works, which in their original and detached form are now very rare, were collected and published in 1737, under the title of *The Political Works of Andrew Fletcher, Esq.*

(Earl of Buchan's *Essay on the Life and Writings of Fletcher of Saltoun;* Chambers's *Biog. Dict. of Eminent Scotsmen,* &c. &c.)

FLETCHER, *Giles* and *Phineas,* two celebrated religious poets of England, were the sons of Dr Giles Fletcher, English ambassador in 1558 at the court of Russia, and the cousins of the distinguished dramatist, John Fletcher.

Giles, the elder of the two brothers, was born about the year 1580; was educated at Trinity College, Cambridge; took orders in the Church of England, and died in 1623 at his living of Alderton in Suffolk. The only poem which he has left us consists of four several parts, joined together under the common title of "Christ's Victory and Triumphs." It is a kind of narrative of the redemption of man, reminding us to some extent of Milton's epic, and bearing, in form at least, a still more striking resemblance to that of Spenser. The animation of the narrative, the liveliness of the fancy, and the deep pathos that pervades the whole work, contribute to make it in its totality one of the most beautiful religious poems in any language, and, as Southey remarks, "will preserve the author's name while there is any praise." It has been complained that it abounds too much in allegory; and though this charge may be partly true, the interest of the poem is admirably maintained to the last. The work itself is written in a sort of variety of the Spenserian stanza, and its beauties are set in phraseology so marked and peculiar as to be readily recognised wherever quoted. This characteristic is still more striking from the antitheses and apparent paradoxes in which Fletcher delighted. Such lines as the following occur frequently throughout this poem:—

"The silence of the thought loud-speaking hears;"—
"The death of life, end of eternity;"—
"The obsequies of him that could not die."

Phineas, the younger brother of Giles, was born about 1584; entered King's College, Cambridge, in 1600; graduated there and took orders in the church, and in 1621 became vicar of Hilgay in Norfolk, where he died about 1660. His principal work—*The Purple Island; or, The Isle of Man*—is the nearest thing in English literature to an imitation of Spenser. It is confessedly an allegory, intended to symbolize all the functions of the human mind and body, especially the latter, and is quite unworthy of the fame it once enjoyed. It is wearisome throughout; and though it contains occasional passages of much beauty, it can hardly be said, on the whole, to repay perusal. Phineas Fletcher wrote, besides *The Purple Island,* some eclogues, a drama entitled *Sicelides,* and a poem in Latin hexameters, called *De Literatis antiquæ Britanniæ, præsertim qui doctrinâ claruerunt, quique collegia Cantabrigiæ fundârunt.*

FLETCHER, *John.* See BEAUMONT AND FLETCHER.

FLETEWOOD, WILLIAM, an English lawyer, and recorder of London in the reign of Elizabeth, was a natural son of Mr Fleetwood of Hesketh, in Lancashire. He was educated at Oxford, and studied law at the Middle Temple. In 1569 he was appointed recorder of London, and during his holding of this office he exercised his power very zealously against popish priests and their chapels. He was eminent as an orator and politician. As an author his chief works are—*An Oration,* spoken before the Lord Mayor at Guildhall; *A Table to Plowden's Reports; The Office of a Justice of the Peace,* 1658; *Annalium tam Regum Edwardi V., Richardi III., Henrici VII. quam Henrici VIII.; Titulorum ordine Alphabet. et Elenchus,* 1579 and 1597. He died in 1593.

FLEUR-DE-LIS, in *Heraldry,* a charge representing a lily, but conjectured to have originally been intended to represent the head of a javelin. The fleur-de-lis has been borne from a very early period in the royal arms of France.

FLEURY, ANDRÉ HERCULE DE, CARDINAL, the celebrated minister of Louis XV. of France, was born in 1653 at Lodève, in Languedoc. He was educated by the Jesuits at Paris, and became successively almoner to Marie Thérèse, queen of Louis XIV., in 1699 bishop of Frégus, and ultimately preceptor to the young prince, who afterwards succeeded to the French throne as Louis XV. On the death of the Regent Orleans in 1723, Fleury was made a member of the Council of State, and in 1726 (though at that time in his seventy-third year), was called to the office of prime-minister, which he held till his death in 1743. At the time when Fleury was called to the direction of affairs, the condition of France was truly deplorable. The nation was impoverished and worn out, and the exchequer emptied by the long wars of the Grand Monarque and the extravagances of the regent. Commerce was annihilated, public credit ruined, the government held in contempt, and the church distracted by internal dissensions. Fleury immediately set himself to reform these abuses, and by his honesty, economy, disinterestedness, and decision, effected very great reforms. Indeed the only reputable part of Louis the XV.'s reign was that in which the helm of state was guided by the hand of the aged cardinal. Though he was a confirmed friend to peaceful measures, he was twice driven by court intrigues to take part in foreign wars; first, in the case of Stanislaus Leczinsky, the dethroned king of Poland, whose daughter Louis had married; and afterwards in that of the Austrian succession, of which he did not live to see the end. One of the most useful acts of Fleury's administration was the completion of the Royal (now the Imperial) library, which he enriched with many valuable manuscripts, chiefly in the oriental languages.

FLEURY, *Claude, Abbé,* was born at Paris, December 6, 1640. Destined for the bar by his father, he was placed at the college of Clermont (now that of Louis-le-Grand), where the sons of the first families of France were educated. After passing brilliantly through the regular collegiate studies, he was nominated an advocate to the parliament of Paris in 1658, and continued during nine years to pursue the legal profession. Feeling a strong desire to enter the church, being fond of solitude, but especially influenced by the religious sentiments which he had imbibed during his early education, he renounced the law, which, with history and literature, up to this time had formed the principal objects of his study, in order to devote himself to theology exclusively. He had already been some time in holy orders, when Louis XIV., in 1672, selected him as tutor of the princes of Conti; and so well did he acquit himself in this office that the king intrusted to him afterwards the education of the Count of Vermandois, one of his natural sons; and at the death of the young prince, Fleury received as recompence for his services the abbey of Loc-Dieu, in the diocese of Rhodez. Five years after this he was appointed sub-preceptor of the dukes of Burgundy, of Anjou, and of Berri. He thus became intimately associated with Fénélon, the chief preceptor of his royal pupils. In 1696 he was selected to fill the place of La Bruyère in the French academy; and on the completion of the education of the young princes, the king bestowed upon him the rich priory of Argenteuil, in the diocese of Paris. On assuming this benefice he resigned that of the abbey of Loc-Dieu, thus setting an example of rare disinterestedness. It was about this time that he decided, according to the suggestions of his friends, on commencing his great work, for which he

had long been collecting materials—the *Histoire Ecclésiastique.* Hitherto France did not possess any work of equal merit in this department of literature. There existed many works more or less voluminous on matters of doctrine and discipline, but no one had written a history of the church—a complete and scientific exposition of the progress of Christian society, of its organization and its primitive doctrine, of its varied changes in connection with the state, of the successive development of its institutions, of all the modifications introduced into its symbols and its rites. Of this great work the French say: "One work only was wanting at that time which should collect together the scattered information of the epoch, and that was the very time to publish it." Fleury had evidently the intention of writing a history of the church for all classes of society; but at the time in which his great work appeared it was less religion than theology that absorbed the attention of the clergy; and his work, as well as all those that had been published previously, is more a work for the student than one for the people, dwelling as it does very particularly on questions of doctrine, of discipline, of supremacy, and of rivalry between the priesthood and the imperial power, while it notices very slightly general questions affecting religion and morality. Notwithstanding all this, the success of the *Histoire Ecclésiastique* was very great. The first edition, printed at Paris, in 20 volumes 4to, 1691, was followed by many others, among which may be mentioned that of Brussels, in 32 vols. 8vo, 1692, and that of Nismes, in 25 vols. 8vo, 1778 to 1780. The work of Fleury only comes down to the year 1414. It was continued by T. Claude Fabre down to 1698, in 16 vols. 4to, and thence by Alexandre Lacroix down to 1778. These supplementary continuations are very inferior to the labours of Fleury; they are mere compilations of facts, with little criticism, and still less talent. In consulting the work of Fleury and its supplements the general table of contents, published by Rondel, Paris, 1758, 1 vol. 4to, will be found very useful. Translations have been made of the entire work into Latin, German, and Italian.

Fleury has left other works, though not at all so celebrated. These are *Mœurs des Chrétiens*, Paris, 1662; and *Mœurs des Israélites*, Paris, 1772—two works at first published separately, but afterwards united and published in 3 volumes 12mo, written with elegance and precision; *Catéchism Historique*, first published in 1679, 12mo; *L'Institution au droit Ecclésiastique*, Paris, 1687: besides several minor works of little importance.

FLEURUS, a small town of Belgium, province of Hainault, 7 miles N.E. of Charleroy, and remarkable for the battles fought there in 1622, 1690, 1794, and 1815. Pop. (1851) 3483.

FLEXOR, in *Anatomy*, a name applied to several muscles, whose office is to bend the parts to which they belong; in opposition to the *extensors.*

FLINDERS, MATTHEW, a distinguished English navigator, was born at Donington, in Lincolnshire, in 1760. After serving in a variety of subordinate capacities, he was commissioned by the English government in 1801 to circumnavigate and explore New Holland, to our knowledge of which country he contributed more than any other discoverer of that day. He underwent the most dreadful hardships and successfully braved the greatest dangers in the course of this expedition. On his way home he was driven by stress of weather to Mauritius, where he was seized by the French authorities, and detained in confinement for six years. Reaching home at length in 1810, he began to prepare for press the narrative of his voyage and adventures. This work was published in 1814 (on the very day on which its author died), under the title of *A Voyage to Terra Australia, &c., in the years* 1801, 1802, *and* 1803, *in H.M. ship Investigator, and subsequently in the armed vessel Porpoise, and Cumberland schooner,* in two vols., with Atlas. For a detailed account of his discoveries, see art. AUSTRALIA, vol. iv., pp. 253–4.

FLINT, silicious mineral. See MINERALOGY. It consists of 98 silica, 0·50 lime, 0·25 alumina, 0·25 oxide of iron, and 1·0 loss. This mineral occurs of various colours, but generally yellowish or dark gray, and usually in a compact amorphous body, of various shapes. It is widely dispersed over the world, occurring chiefly in the chalk formations, but especially in limestone. Its principal use is for gun-flints, and for striking light with steel; and it also forms, when reduced to powder, an ingredient in procelain and glass. The manufacture of gun-flints is very simple, and is performed with an iron mallet and chisel. A dexterous workman will make 1000 in a day.

FLINT-GLASS. See GLASS-MAKING.

FLINT (Welsh *Fflint. Tegcingl*), the capital of the county of the same name, a market, borough, and seaport town, N. Wales, 173 miles N.W. from London, situated on the south shore of the estuary of the Dee, on the narrow strip of flat land lying between the sea and the hills of the inland parts of the county. The houses are for the most part well built, but the place has altogether an air of decay. The harbour and wharfs have been lately much extended; but the accumulation of sand is so great that there is little or no prospect of any important increase of shipping. The principal exports are coals, lead in a manufactured state, and iron. Ship-building is carried on to some extent in the smaller description of vessels. The town possesses a handsome Gothic church, and five chapels belonging to the different Dissenting bodies. There are also a guildhall and county jail, and handsome schools.

Close by the shore stands the ruins of the ancient castle of Flint. It is said to have been built by Edward I.; and it was here that Percy delivered Richard II. to Bolingbroke. It was dismantled by order of the House of Commons in the time of the civil wars in 1646.

The borough along with Caergwrle, Caerwys, Overton, and Rhyddlan, returned one member to parliament from 1536 to 1832; since the latter period Holywell, Mold, and St Asaph have been added as contributing boroughs; constituency in 1852, 817. The political influence is chiefly in the hands of Lord Mostyn. Population in 1851, 3296; inhabited houses, 693. The assizes are now held at Mold.

FLINTSHIRE (Welsh, *Sir Fflint*), a maritime county in North Wales. This county is made up of two separate portions lying at a distance of 8 miles from each other. The main portion is bounded on the N. by the estuary of the Dee; on the N.E. and E. by Cheshire; and on all other sides by the county of Denbigh. Its greatest length is from S.E. to N.W. about 26 miles, and its breadth is about 12 miles. The detached and smaller portion of this county lies to the S.E. It is bounded on the N. by Cheshire; on the E. and S. by Shropshire; and on the W. by Denbighshire. It is about 9 miles long by 5 broad. The whole of the county possesses an area of 289 square miles or 184,905 acres, and it is the smallest of the Welsh counties. The origin of the name is involved in obscurity. The greater part of this county is situated on the coal measures, and the other members of the group of carboniferous rocks. The northern rim of the North Wales coal-field extends along nearly the whole of its northern boundary. Along the southern edge of the coal strata the millstone grit extends in a continuous line, which, further south, is followed by the carboniferous or mountain limestone; and in the extreme south by the upper Silurian (Wenlock) rocks. The eastern as well as the western extremities of the main portion of the county, and also the whole of the detached part, are situated on the new red-sandstone formation.

Along the southern boundary the Wenlock rocks rise into a mountain chain of considerable elevation, forming the northern limb of the Berwen range; and terminating about

Flintshire.

a mile from the shore of the Dee, near the western extremity of the county. The small portion of land lying still further west is flat, and much of it consists of rich alluvium embracing a portion of the well-known Rhyddlan marsh, and forming part of the celebrated Vale of Clwyd (see DENBIGHSHIRE). The watershed of the Berwens forms the county boundary for a considerable distance along the south; and the summit of a member of this range, the Moel Fammau, common to this county and Denbighshire, rises to the height of 1845 feet. The general character of the county is mountainous, although the hills, with the exception of those already mentioned, do not rise to any great elevation. Besides the tract of flat rich land on the extreme west, there is a similar tract of no great extent in the same geological formation in the east; and from the one to the other there extends along the southern shore of the Dee a narrow strip of rich alluvial soil. The detached portion of the county is also flat.

Some of the small valleys are very beautiful, although not equal to those of other parts of North Wales. With the exception of that part of the vale of Clwyd embraced by this county, the vale of the Alyn is the most important.

The principal rivers are—the Dee, forming part of the northern boundary of the main part of the county, and also the eastern boundary of the detached portion; the Clwyd, which forms the western boundary for about 3 miles; the Elwy, which enters the county near the city of St Asaph in the west, and after joining the Clwyd falls into the sea at Rhyl; and the Alyn, which, rising in the Berwens, near the eastern extremity of the county, after a very tortuous course, flowing first west and then east, is discharged into the Dee, after traversing part of Denbighshire.

Flint possesses few lakes, and these are small and unimportant. The principal ones are Llyn Helyg in the N.W., and Llyn Cyffynwy in the S.E.

Owing to its proximity to the sea the climate is for the most part mild; although, of course, on the Berwens and other elevated land the air is keen. The cultivated crops consist of wheat, beans, oats, barley, Welsh bere, rye, vetches, pease, hay, potatoes, turnips, mangold-wurtzel, and carrots. Clover seed is also grown, but not to any great extent. The eastern part of the county is liable to be flooded by the overflowings of the Dee, and is mostly in pasture. The farms are of considerable size, and the farmers are more intelligent than in most other parts of Wales. Agriculture is therefore in a more advanced state. In addition to the crops, already mentioned, there is a good deal of cheese and butter made; there is also a very considerable production of mutton and beef, for which a ready market is found among the thickly planted mining population. Wool and oak bark as well as timber are produced to a considerable extent, but it is for its mineral wealth and manufacturing industry that the county of Flint is chiefly remarkable. In addition to its numerous coal mines and limestone quarries, it contains some of the richest lead and calamine mines in the British islands, and large quantities of carbonate of baryta have been lately found there. There are numerous smelting works; and at those at Bagillt a very large proportion of all the lead ore raised in the world is smelted, and has the silver separated from it. There is a very extensive foundry and engine manufactory at Mold; and there are numerous iron, chemical, coarse pottery, and other works scattered all over the more accessible parts of the county, and giving employment to a very large number of work-people. The shipping trade is not extensive, for, owing to the gradual silting up of the Dee, only vessels of light draught can enter the Flintshire ports.

The lower parts of Flintshire are well supplied with means of communication and transport, for, in addition to the water carriage on the Dee, extending the whole length of the country, the Chester and Holyhead railway traverses its greatest length, and the Chester and Mold railway penetrates to the centre, and opens up a communication with all parts by means of the valley of the Alyn.

Flip ‖ Flodden Field.

The principal towns are Flint, Mold, St Asaph, Rhyl, and Holywell; besides which there are several smaller ones, the principal of which are Rhyddlan, Hawarden, Caergwrle, Caerwys, and Overton. The county is divided into 28 parishes, and is for the most part in the diocese of St Asaph. It returns one member to parliament, and has done so since 1536. The political influence is almost entirely in the hands of Lord Mostyn, and the political opinions are chiefly of a liberal tendency; constituency in 1852, 2912. The average gross rental of the county is as high as 24s. 9d. per acre. The annual value of real property paying income tax in 1851 was L.399,261, and of property assessed to the relief of the poor in 1850, L.222, 16s.

The population of the county by the census of 1851 was 68,156, giving an average of 235 persons to a square mile, or 2·7 acres to a person. Of the total numbers 34,452 were males, and 33,704 females. Flint is thus, next to Glamorgan, the most densely peopled county in Wales, and contains rather more than four times as many people to an acre as Radnor, the most thinly peopled of the Welsh counties. The number of inhabited houses was 14,041, uninhabited 798, building 80, giving an average of 49 houses to a square mile, and 4·8 persons to a house. The following table gives the census returns for the last fifty years:—

Years						Increase of Population per cent. in Fifty Years.
1801.	1811.	1821.	1831.	1841.	1851.	
39,469	45,937	53,893	60,244	66,919	68,156	72

It is calculated that about eight per cent. of the population live by agriculture, and nine per cent. by trade, manufactures, &c. About one-fourth of the whole are in the condition of labourers, servants, &c. About thirteen hundred persons possess independent means, and five hundred follow professions.

In 1847 the total number of children of the working classes at day schools within the county was 7586. Of schools 60 were church or "national" schools, with 4893 scholars; 1 Calvinistic Methodist, with 48 scholars; 2 Independent, with 103 scholars; 2 Roman Catholic, with 55 scholars; 5 British and Foreign, with 806 scholars; 5 of no denomination, with 311 scholars; 2 workhouse schools, with 112 scholars; 1 factory school, with 30 scholars; and 53 private adventure, with 1228 scholars. It appears that the average annual income of the teachers from all sources was only L.25, 5s. 10d. The total number of Sunday schools was 133, with 15,310 scholars. Of these 26 were Church, with 3841 scholars; 2 Baptist, with 161 scholars; 43 Calvinistic Methodist, with 5092 scholars; 27 Independents, with 2377 scholars; 34 Wesleyan Methodist, with 3779 scholars; 1 of other denominations, with 60 scholars. In 51 of these schools instruction was given in the Welsh language only; in 18 in the English language only; in 62 in both languages; and in two, which language was not ascertained. A great proportion of the population use the English language, and, as may be supposed, from the proximity to England, and the great industrial progress of this county, the manners and habits approach more nearly to the English type than in most other parts of Wales.

There are numerous fine gentlemen's seats throughout this county; and there is a cathedral and bishop's palace at St Asaph. (J. G—W—D.)

FLIP, a mixed drink composed of malt liquor, brandy, and sugar, and esteemed among sailors.

FLODDEN FIELD, in the county of Northumberland, eight miles S.E. of Coldstream, is memorable as the scene of the battle fought there on 9th September 1513 between the

English under the Earl of Surrey and the Scotch commanded by James IV., in which the latter were totally defeated and their king slain. See SCOTLAND.

FLOOD. See DELUGE.

FLOOR, in building. See BUILDING. Boards for flooring may be prepared with great despatch by means of the *flooring-machine*, by which the several operations of sawing, planing, grooving, and tonguing, are all carried on at the same time by a series of saws, planes, and revolving chisels.

FLORA, in *Roman Antiquity*, the goddess of flowers. There is an old tradition extant in the Latin classics to the effect that Flora was originally a courtezan, who amassed a large fortune, which she bequeathed to the Roman people on condition of being annually commemorated in a festival. Her worship, however, dates from a very remote period, as it is recorded that Tatius built in her honour a temple, for the service of which a special flamen was consecrated by Numa. The temple of Flora was situated near the Circus Maximus. Flora is commonly represented as a woman in the very prime of life, bearing in her left hand a cornucopia filled to overflowing with flowers of every kind.

FLORA, in *Botany*, denotes a catalogue or account of flowers or plants.

FLORALES LUDI, or FLORALIA, in *Roman Antiquity*, a festival in honour of Flora, which lasted for five days, from April 28 to May 2. It is said to have been instituted in the year 238 B.C., and to have been afterwards discontinued in consequence of the license and immorality to which it gave occasion. In the year 173 B.C., however, it was restored at the command of the senate, as the blossoms had suffered very severely in the spring of that year from the severity of the weather. The ædiles, as usual, presided over these games, which consisted chiefly in the exhibition of mimic fights and indecent dances performed by women of loose character, who used also to throw beans and chick-peas among the crowd. Instead of wild beasts, hares and rabbits were let into the arena, and chased about for the public amusement. The spot where the Floralia were held is still called the *Campo di Fiora*, and at this day forms one of the squares of Rome, and is used as a market-place.

Festivals very like the floralia are still celebrated throughout Italy, where they have always been very popular. Floral games, or *jeux floraux*, was the name given to the reunions held in the south of France, especially at Toulouse, where garlands of flowers were awarded as prizes to successful competitors in the poetical contests.

FLORENCE, (Italian *Firenze*, and in old writers *Fiorenza*,) a famous city of Italy, capital of the grand duchy of Tuscany, is situated on the river Arno, which divides it into two unequal parts. The important place which this city occupies in history, the beauty of its situation, the treasures of art which it contains, all contribute to its interest and celebrity.

"Girt by her theatre of hills, she reaps
Her corn, and wine and oil, and Plenty leaps
To laughing life, with her redundant horn.
Along the banks, where smiling Arno sweeps,
Was modern Luxury of Commerce born,
And buried learning rose redeemed to a new morn."

Childe Harold, Canto iv., 48.

The origin of Florence is not clearly ascertained; but it probably owes its rise to the establishment of a Roman colony here by Octavianus after the victory of Perusia, though there seems some reason to believe that one had been established here about 40 years previously by Sulla. The only important notice of Florence to be met with in the ancient writers is in Tacitus, *Annal.* i. 79, where it is mentioned among the municipia which, in the reign of Tiberius, sent deputies to Rome to remonstrate against the intended diversion of the course of the Clanis into the Arnus, by which their town and territory would have been rendered liable to inundations. The only remains of the Roman period are some relics of an amphitheatre near the church of Santa Croce, and a few inscriptions. In 406 Florence was besieged by the Goths under Radagaisus and reduced to the last extremity, till the arrival of Stilicho with an army, who defeated the barbarians and relieved the town. It was almost entirely destroyed by Totila, king of the Goths, in 541, and remained in ruins and obscurity till the end of the eighth century, when it was rebuilt by Charlemagne after that monarch had conquered the Lombards. From this time it rose rapidly into importance, and at length assumed a republican form of government. During the fourteenth and fifteenth centuries it was one of the most opulent cities in Europe; and from the many eminent and learned men who flourished here, under the patronage of the Medici family, at a time when the great nations of Europe were only beginning to emerge into civilized existence, it has justly acquired the designation of "Etruscan Athens." See ITALY, TUSCANY, &c.

The city of Florence is situated in the fertile and well-wooded *Valdarno*, or vale of the Arno, encircled by the Apennines. The magnificent and stately character of many of its buildings, the numerous bright villas scattered about the vale and on the slopes of the hills, and the fine forms of the mountains which inclose the prospect, have earned for it the title of *Firenze la Bella*. Behind the city rise hills covered with olive and fig trees and other plants, natives of warmer climates; beyond are chestnut-covered mountains; while in the distance the naked and rugged summits of the lofty Apennines rise to the height of more than 3000 feet above the plain. The city extends along both banks of the Arno, which intersects it from S.E. to N.W. Its form is that of an irregular pentagon, of which the greater portion is on the right or northern side of the river. It is inclosed by old walls nearly six miles in circuit and pierced by eight gates. They are still unbroken, except where the citadels of Belvedere and the *Fortezza da Basso* have been inserted, but are totally useless as a means of defence; and the towers which ornamented their circuit have generally been demolished or lowered to the level of the curtain. That portion of the Arno within the walls is crossed by four bridges, the finest of which is the Santa Trinitâ, adorned with statues, and having a central arch of 95 feet span. Beyond the walls, on each side, was a suspension bridge, but one of these was carried away by the great flood of 1844. In the central or older portion of the town the streets are generally narrow and irregular, but in the more modern parts they are wide, straight, and well paved. Florence contains a great number of magnificent edifices and squares, generally adorned with statues, columns, or fountains. First among its public buildings is the cathedral, commenced by Arnolfo in the end of the thirteenth century, and completed in the fifteenth by Brunelleschi. It is 454 feet in length; the transept is 334 feet long; height of nave 153, and of side aisles $96\frac{1}{2}$ feet. The magnificent cupola by Brunelleschi excited the admiration of Michael Angelo, and is said to have served him as a model for that of St Peter's at Rome. It is of an octagonal form, 384 feet high, and $138\frac{1}{2}$ in diameter. The interior of the building is rather dark from the smallness of the windows, and the deep and rich colours of the stained glass with which they are filled. The exterior is almost entirely cased in marble, and the pavement is tesselated with red, blue, and white marble. Detached from the cathedral, and like it cased in marble, is the belfry, a light and elegant tower 276 feet in height. In front of the principal entrance of the cathedral stands the baptistery of St John, an elegant octagonal building. These, like most of the other churches and public buildings, are richly adorned with works of art. The church of Santa Croce, called the Pantheon of Florence, is interesting from the number of sepulchral monuments which it contains; among

which are those of Michael Angelo, Galileo, Machiavelli, and Alfieri. The church of San Lorenzo, built by Brunelleschi, contains the mausoleum of the Medici family. Annexed to it is the building begun by Michael Angelo and finished by Vasari, containing the Laurentian library, of above 120,000 volumes, and a valuable collection of MSS. amounting to more than 9000. The *Palazzo Vecchio*, now occupied by government offices, is a square massive-looking structure, surmounted by a tower 268 feet in height. The *Palazzo Pitti*, the residence of the grand duke, is enriched by numerous fine statues, busts, and paintings, and has a library of 70,000 volumes and 1500 MSS. Attached to it are the extensive gardens of Boboli, laid out in rectangular walks flanked with cut trees, and having terraces, statues, and fountains. Connected with these gardens is a botanical garden, a museum of natural history, an anatomical collection modelled in wax, and a fine library. The Palazzo Riccardi is used partly for government and partly for literary purposes, and contains a library of about 20,600 volumes and 3600 MSS. The Magliabechi, a library in the *Uffizi*, obtains a copy of every book published in the Tuscan states, and contains upwards of 150,000 volumes and 12,000 MSS. The Marucellian library contains about 50,000 volumes. The *Uffizi*, erected after a design of Vasari by Cosmo I., forms three sides of a parallelogram. In the upper floor of this building is the celebrated Florentine gallery, one of the richest existing collections in sculptures, medals, bronzes, paintings, and other works of art. Among its statuary is the famed *Venus de'Medici*, discovered in the sixteenth century in the Villa Hadriana, near Tivoli. The whole of the left arm and part of the right are modern, having been restored by Bandinelli. The collection of paintings comprises superb specimens of all the best schools, and is said to surpass even that of the Vatican. Florence contains no fewer than 170 churches, 89 convents, 2 ducal and many other palaces, 12 hospitals, and 8 great and small theatres. The literary and educational institutions are numerous and important. Chief among these is the academy *Della Crusca*, established in 1582, to which is united the University of Florence, founded in 1438. Its grand object is the sifting or purifying of the Italian language, and hence its name *Crusca*, chaff, or husk of corn. There are also academies of the fine arts and of agriculture, a medico-chirurgical college, an athenæum, and a number of other literary societies. The charitable institutions are numerous and varied, including asylums for the deaf and dumb, blind, orphans, and an association of the higher classes for ministering to the necessities of the sick and infirm poor. The inhabitants of Florence are industrious, cheerful, and hospitable. The chief manufactures are silks, straw-hats, carpets, porcelain, mosaic work, perfumery, and jewellery. The salubrity and beauty of the town and neighbourhood; its libraries, reading-rooms, and collections in the fine arts; its mild and liberal government; and the moderate price of provisions, render this the most pleasant place of residence in Italy, and have attracted to it a great number of English families. It has produced many individuals eminent in arts, science, and literature: among others, Machiavelli the political writer; Dante Allighieri, Luigi Rucellai, Menzini, and Filicaja, poets; Guicciardini the historian, Michael Angelo Buonarotti the artist, Galileo the astronomer, Amerigo Vespuccio the navigator, Lulli the musician, and the artists of the school of this city. Florence is situated N. Lat. 43. 46. 41., E. Long. 11. 15. 55., and is 182 from Genoa, 186 from Venice, 72 from Bologna, 53 from Pisa, 41 from Siena, and 190 from Rome. It is connected by railways with Pistoja, Pisa, and Siena. Pop. (1854) 115,675.

FLORENCE, an ancient English gold piece coined by Edward III., of six shillings sterling value.

FLORES or FLORIS, an island in the Indian Archipelago, about 200 miles in length, and 42 to 50 in extreme breadth, lying between E. Long. 119. 55. and 123., and S. Lat. 7. and 9. 5. The surface is hilly, particularly towards the south, where there are several high volcanic mountains, but the interior is very imperfectly known. The principal port, Endé, on the south has an excellent harbour. The chief products are cotton, rice, sulphur, saltpetre, sandalwood, bees'-wax, horses, and slaves; and its trade is carried on principally with Singapore. The native inhabitants are Timuri, but the coasts are chiefly inhabited by Bugis and Malays. The Dutch have a fort on the N. coast called Pota. Flores gives name to the strait which separates it on the E. from Solor and Adenar. This is also the name of one of the Azores. See AZORES.

FLORIAN, JEAN PIERRE CLARIS DE, was born in 1755 at the Château of Florian, near Sauve, in Languedoc. His uncle, who had married a niece of Voltaire, introduced him on one occasion to that philosopher in his retreat at Ferney, and the young Florian remained with the dictator of French literature till his fifteenth year. In 1768 he attached himself to the Duc de Penthièvre, who first of all gave him a commission in a dragoon regiment, and afterwards made him one of his own gentlemen in ordinary. In 1783 Florian produced his first work *Galatée*, a professed imitation of the *Galatea* of Cervantes, which was followed two years later by his *Numa Pompilius*, an equally undisguised imitation of the *Télémaque* of Fénélon. In 1788 appeared *Estelle*, a pastoral romance, bearing a strong general resemblance to the *Galatée*, but esteemed superior to that, and indeed to most of the author's other works. In 1791 appeared his romance of *Gonzalve de Cordoue*, which, as well as the prefatory history of the Moors, was warmly commended. But Florian's chef-d'œuvre is his collection of fables, the best beyond a doubt that has appeared in France since the days of La Fontaine. On the breaking out of the French Revolution, Florian retired to Sceaux, where, however, he was soon discovered and dragged to prison by the Parisian sans-culottes. During his confinement he wrote *Guillaume Tell*, the weakest production of his mind. His imprisonment was not of long duration, but it injured his health so materially that he only survived his release by a few months. Florian died September 13, 1794, having just reached his fortieth year. After his death appeared his translation or rather his trashy abridgment of *Don Quixote*, which has been much censured for its want of humour. The best collective edition of Florian's works is that of 1812, in 16 vols. 18mo.

FLORIDA, one of the most southern of the United States of North America, is a peninsula stretching far into the Gulf of Mexico, and to the Atlantic Ocean, comprised between the parallels of 25. and 31. N. latitude, and the meridians of 80. and 87. 35. W. longitude. It is 350 miles in length, and from 50 to 250 in breadth, containing 59,268 square miles. Florida is bounded on the N. by Alabama and Georgia, E. by the Atlantic Ocean, S. and W. by the Gulf of Mexico. During the greater part of the sixteenth century, however, the southern part of the eastern coast of North America was comprehended under the name of Florida; and in 1763, when ceded to Great Britain by Spain, it extended as far W. as the Mississippi, the northern boundary being the St Mary's river, from the ocean to its source, thence by a right line to the junction of the Flint and Appalachicola rivers, thence up the Appalachicola to the parallel of 31. N., and thence due W. on that parallel to the Mississippi river. That portion lying between the Mississippi and Perdido rivers is now included in the states of Lousiana, Mississippi, and Alabama, while that part lying E. of the Perdido is in Florida.

It is now generally conceded that Florida was first discovered in 1497 by Sebastian Cabot, a Venetian in the English service, whence a right to it was claimed by the English; and it was included with Georgia in the charter

Florida. granted by Charles II. to Carolina. In 1512 it was more fully explored by Juan Ponce de Leon, a companion of Columbus in his second voyage. He embarked from Porto Rico March 3, 1512, with three ships fitted out at his own expense. On Easter Sunday, called by the Spaniards "Pascua Florida," land was seen, to which he gave the name Florida. He was subsequently appointed governor, and attempted, in 1521, to colonize the newly discovered land; but he was attacked by the Indians, many of his men were killed, and he himself mortally wounded.

In May 1539, Hernando de Soto arrived in the bay of Spiritu Santo, and passed across the country to the Mississippi. In February 1562 the French Calvinists sent an expedition under the command of Ribault, who discovered the St John's River; and taking formal possession of the continent, left a small colony on Lemon Island, while he returned to France. The colonists were hospitably received by the natives, but suffered many hardships, and were on the point of abandoning their settlement when Ribault again arrived from France, bringing supplies and reinforcements.

But the Spaniards, who not yet renounced their claim, actuated by jealousy against the Calvinists, sent an expedition under Pedro Melendez, who arrived in August 1565, and on the 4th day of September attacked and captured the French, who were all hanged on trees, with the inscription "not as Frenchmen, but as heretics." Three days afterwards the Spaniards landed in the harbour of St Augustine, on the Atlantic coast, and laid the foundation of that town, which is the oldest, by more than forty years, in the United States. Houses in it are yet standing which are said to have been built before Virginia was colonized.

In 1586, St Augustine was taken and pillaged by Sir Francis Drake. In 1597 the French, under Dominic de Gourges attacked and defeated the Spaniards, and, by way of retaliation, hung their prisoners on trees, with the inscription, "not as Spaniards, but as assassins."

In 1702 Col. Moore besieged the town for three months; but the Spaniards coming to its relief, he was obliged to retreat. Another attempt was made in 1740 by General Oglethorpe of Georgia to take St Augustine, but without success. In 1763 Florida was ceded to Great Britain by Spain, who received Havana in exchange. The British government subsequently gave great encouragement to agriculture, and numerous colonists poured into the country from various parts of Europe, and the settlements were in a most flourishing condition. It was, however, by a well-concerted scheme of the Spaniards, recaptured in 1781, and guaranteed to them in the peace of 1783. In 1821 Spain ceded the Floridas to the United States, and in July following it was, in behalf of the latter, formally occupied by General Andrew Jackson. Since its acquisition by the United States, Florida has been the seat of many sanguinary conflicts with the Seminoli Indians, led on by their daring chief Osceola. The savages, although a mere handful, managed to baffle for seven years the United States soldiers, by retreating to their swamps; and before they were finally subdued, in 1842, the expense to government was many millions of dollars. In 1846 the greater part of the tribe was removed beyond the Mississippi river, in pursuance of a treaty made with the U.S. government. In 1838 a state constitution was adopted preparatory to admission into the Union, which, however, was not consummated until March 3, 1845.

The executive power in Florida is vested in a governor elected by the people for four years, and receiving a salary of $1500 a-year. The legislative power is in the hands of a senate of 19 members elected biennially, and a house of representatives of 40 members, elected annually, and both by popular vote. The judiciary consists, 1st, of a supreme court composed of a chief and two associate judges, who hold four sessions annually, one in each of the following places—Tallahassee, Jacksonville, Tampa, and Marianna; and, 2d, of four circuit courts. Florida has but one member in the House of Representatives, and three electoral votes for the president. The assessed value of property in 1850 was $22,784,837, ordinary expenses, $45,000 per annum.

Chief towns—Tallahassee, pop. 1391; Jacksonville, pop. 1045. Tallahassee is the capital. Florida is generally level, probably never elevated more than 250 or 300 feet above the sea. The southern part of the peninsula is covered with large sheets of water called the *Ever-glades*, of immense extent, and filled with islands, and which, it is supposed, may be rendered available by drainage. The central portion of the peninsula is somewhat elevated, the highest point being 170 feet above the level of the ocean, and gradually declining towards the coast on each side.

Bays and rivers. The western coast of the state has a number of bays, viz., Chatham, Charlotte Harbour, Tampa, Appalachee, Appalachicola, Choctawatchee, and Pensacola bays. The last affords an excellent harbour. There is also a chain of lakes running through the middle of the state, the largest and most southern of which is Lake Okechobee. The rivers are numerous, and are navigable for second-class vessels. In the N.W. is the Perdido, a small river separating Florida from Alabama, followed in order by the Escambia, the Blackwater, the Yellow-water, the Choctawatchee, and the Chipola, but none of great length; and all entering from the state of Alabama, discharge their waters in the Gulf of Mexico, with the exception of the Chipola, an affluent of the Appalachicola, which last also flows through Florida.

The rivers flowing into the Atlantic are the St Mary's (dividing Florida from Georgia), the St John's river, and Indian river. The St John's is navigable for 100 miles by vessels drawing 8 feet water. Among the other rivers on the western coast of Florida may be mentioned the Ocklockonee, the Suwanee, the Amasura, and the Charlotte.

Soil and productions. The soil of this state is generally sandy, except in the hummocks, where it is mixed with clay; yet, owing to the mild climate, it is highly productive in many parts. The best lands, however, of the state lie useless at present for want of drainage, and can be had at $5 or $10 per acre. Florida is particularly well adapted for grazing. The number of farms in Florida in 1850 was 4304, containing 349,049 acres of improved land, and yielding 1,996,809 bushels of Indian corn, 66,586 of oats, 135,359 of peas and beans, 757,226 of sweet potatoes, 1,075,090 lbs. of rice, 998,614 lbs. of tobacco, 18,052,400 lbs. of cotton, 23,247 lbs. of wool, 371,498 lbs. of butter, 18,015 lbs. of cheese, 2510 tons of hay, and 2,750,000 lbs. of sugar; live stock valued at $2,880,058, and slaughtered animals $514,685.

Florida exports about 80,000 to 100,000 bales of cotton annually. The capacity and production, &c., may be stated as follows for the year 1854:

Number of bales of 400 lbs. produced	90,000
Labourers employed	23,000
Acres in cultivation	175,000

Florida abounds in forest trees, among which are the live oak (highly esteemed for ship-building), and other varieties of oak, swamp cypress, pine, hickory, magnolia, dogwood, and laurel. The *Palma christi* or castor-oil bean here becomes a large tree. On the islands and keys box-wood, satin-wood, mastic, and lignumvitæ, abound; arrowroot grows wild, and ginger and cinnamon are easily cultivated. The pine grows in that portion of the state near Indian river. Fruit trees in great variety find a congenial soil and climate in Florida (except in a few seasons of unusual severity). The lime, lemon, orange, olive, cocoa-nut, plantain, pine-apple, banana, guava, citron, pimento, coffee, pepper, cloves, &c., may all be successfully cultivated.

Manufactures. Florida is not a manufacturing state. There were in 1850 but 121 establishments, producing annually $500 and upwards. Of these, the cotton factories employed 28 males;

Florin ‖ Florus.

flour and grist mills, 14; saw and planing mills, 489; turpentine making, 75; tanning and currying, 12; brick making, 97. Value of home-made manufactures, $75,582.

Very little progress has been made in works of internal communication, nor is it to be expected in a state so thinly peopled, and whose settlements for the most part lie contiguous to some navigable waters. In 1853 there were 54 miles of railway completed, one connecting St Mark's with Tallahassee, and the other Iola and St Joseph's.

There is no system of free schools in Florida, nor any college. According to the census report of 1850, there were 69 public schools, and 34 academies and other schools. Schools.

Of the 177 churches in Florida, 56 belonged to the Baptists, 10 to the Episcopalians, 1 to the Free Church, 87 to the Methodists, 16 to the Presbyterians, 5 to the Roman Catholics, and 2 to minor sects, having a total accommodation of 44,960 sittings. Value of church property, $165,400. (J. S. H.) Religion.

Statistics of Florida.

Names of Counties.	Nativities, Dwellings, &c.				Education and Religion.								
	Born out of State.		Dwellings.	Families.	Academies and Private Schools.		Public Schools.		Total educational Income.	White Scholars during year.	Whites 5 and under 20 years old.	Whites over 20 unable to read & write.	Accommodation of churches—persons.
	United States.	Foreign Countries.			Pupils.	Anunal Income.	Pupils.	Annual Income.					
Alachua	854	9	274	274	...	...	30	...	...	79	642	272	635
Benton	325	10	113	117	...	..	60	960	960	93	223	65	875
Calhoun	598	12	165	165	...	...	44	...	...	105	377	95	200
Columbia	1830	8	569	569	...	...	162	2356	2356	278	1471	363	2700
Dade	36	85	23	23	...	...	...	...	...	...	31	15	...
Duval	936	69	451	455	...	...	64	...	...	159	850	165	3050
Escambia	1337	469	563	563	25	$420	269	5280	5700	415	873	197	2500
Franklin	528	273	261	261	100	2900	30	350	3250	152	315	100	1500
Gadsden	2153	25	684	684	180	3600	300	3600	7200	454	1588	49	7300
Hamilton	1021	...	301	302	...	...	...	...	...	97	763	201	1350
Hillsborough	801	283	253	257	60	1000	120	1400	2400	250	485	132	660
Holmes	684	2	185	187	...	...	20	...	...	53	442	168	230
Jackson	2177	18	560	577	40	1000	...	...	1000	221	1233	437	950
Jefferson	1562	39	520	520	47	...	172	4300	4300	426	1173	280	3900
Leon	1828	78	737	737	349	...	54	...	...	400	1195	166	4850
Levy	146	10	64	64	...	...	...	...	...	2	127	15	...
Madison	1902	11	498	498	100	...	140	...	...	185	1153	29	6200
Marion	1358	16	394	394	...	...	60	600	600	128	810	59	1800
Monroe	479	1082	420	443	73	1300	85	1150	2450	241	592	154	1200
Nassau	387	9	188	188	...	...	...	...	...	104	421	133	...
Orange	66	6	55	55	...	...	33	300	300	53	99	20	...
Putnam	379	.7	108	108	...	...	...	...	...	25	186	95	...
St Johns	184	63	321	346	160	1450	50	100	1550	375	552	100	1700
St Lucie	49	50	22	22	...	...	...	...	...	5	17	2	...
Santa Rosa	1347	56	526	527	60	1000	100	1750	2750	239	815	178	1600
Wakulla	724	23	227	229	22	419	20	240	659	86	450	114	1250
Walton	827	37	267	267	35	...	20	...	...	50	639	69	275
Washington	913	20	273	275	...	...	45	...	...	71	575	186	235

FLORIN is sometimes used to signify a coin, and sometimes a money of account. Florin, as a coin, is of different values, according to the different metals, and different countries where it is struck. See MONEY.

FLORINIANI, an obscure Gnostic sect in the early Christian church, who owed their origin to Florinus, a pupil of Polycarp, and a presbyter of Rome, excommunicated by the Bishop Eleutherius. They never numbered among their members any person remarkable either for intellect or influence, and the history of their doctrines is involved in as much obscurity as that of their origin and progress. It is only known for certain, from a passage in Eusebius (*Hist. Eccles.* lib. v., cap. 20), that they adopted the Gnostic heresy.

FLORIS, FRANZ, a distinguished Flemish painter, born at Antwerp in 1520. He began the study of art as a sculptor, but in his twentieth year laid aside the chisel and devoted himself to the more congenial pursuit of painting. A pilgrimage to Italy, and a careful study of the great masters of Italian art, so modified his taste and manner that on returning to his native city he adopted their style and attained such eminence in it as to earn the title of the Flemish Raphael. His best works are his "Twelve Labours of Hercules," and "The Last Judgment," now in the Museum at Brussels; and his "Adoration of the Shepherds," and "Fall of the Rebel Angels," at Antwerp. Floris died in 1570.

FLORUS, LUCIUS ANNÆUS, author of the *Epitome de Gestis Romanorum*, was a native of Spain, or, according to others, of Gaul, and lived under the Emperors Trajan and Hadrian. A good deal of difficulty and variety of opinion prevails as to the identity of this Florus. By some writers he is thought to be the Lucius Julius Florus who lived in the time of Augustus, and to whom Horace addressed two of his epistles; but this position is hardly tenable, as Florus in the introduction to his history talks of the Emperor Trajan as then reigning. By others he is identified with the Julius Florus or Floridus, who lived in the time of Hadrian, and wrote the *Pervigilium Veneris*, an imitation of Horace's *Secular Hymn*. This idea is equally gratuitous with the other. The *Epitome* of Florus gives a condensed view of Roman history from the foundation of the city to the closing of the temple of Janus by Augustus. The details of geography and chronology are not always to be implicitly trusted; but the general view of Roman history is striking and philosophic. The style is inflated and declamatory, and rather that of a panegyrist than of a critical historian. The *Epitome* is chiefly useful as a sort of substitute for the last books of Livy. The best editions of Florus are that of *Titze*, Prague, 1819; and that of *Duker*, Leipzic, 1832, which last is generally regarded as the standard edition.

Flotsam.

FLOTSAM, JETSAM, and LIGAN. In order to constitute a legal wreck the goods must come to land. If they continue at sea, the law distinguishes them by the barbarous

and uncouth appellations of *jetsam*, *flotsam*, and *ligan*. Jetsam is where goods are cast into the sea, and there sink and remain under water; flotsam is where they continue swimming on the surface of the waves; ligan is where they are sunk in the sea, but are tied to a cork or buoy, in order that they may be found again. Jetsam, flotsam, and ligan belong to the king, or his grantee, if no owner appears to claim them within a year. They are accounted so far distinct from legal wreck, that by the king's grant of wrecks, things jetsam, flotsam, and ligan will not pass.—(*Blackstone*, b. i., c. 8.)

FLOUR, St, a town of France, capital of a cognominal arrondissement in the department of Cantal, 33 miles E.N.E. of Aurillac. It stands on a basaltic plateau 300 feet high, at the foot of which flows the Dauzan. The town is ill-built, with narrow and irregular streets; and the houses being constructed of basalt give it a dull and sombre appearance. It is, however, the seat of a bishopric, and has tribunals of primary instance and commerce, a communal college, public library, agricultural society, museum, hospital, and a public fountain. Pop. (1851) 5254.

FLOWER, in botany, that part of a plant which is especially subservient to the production of seed. In its common acceptation the word is used for the flower-bud of a plant when the petals are expanded.

Preserving of Flowers, &c. The preserving of flowers in their natural beauty throughout the whole year has been attempted by gathering them when dry and not too much opened, and burying them in sand; but this, though it preserves their figure well, diminishes the liveliness of their colour.

The flowers of plants are by much the most difficult parts of them to preserve in any tolerable degree of perfection. Sir Robert Southwell has proposed a method of drying plants, by which these defects are said to be in a great measure remedied. For this purpose two strong plates of iron are prepared of the size of a large half sheet of paper, or larger; and in these there must be a hole made near each corner for receiving a screw to bring them closely together. Gather the plants with their flowers when they are quite perfect, in the middle of a dry day; and then place the plant and its flower on a sheet of paper, spreading out all the leaves and petals as nicely as possible. If the stalk be thick, it should be cut in two, so that it may lie flat: if woody, the bark alone should be retained. When all is thus prepared, lay several sheets of paper over the plant, and as many under it; then put the whole between the iron plates, and having screwed them close, put them into an oven after the bread is drawn, and let them lie there two hours. When the flowers are removed from the pressure of the plates, rub them lightly over with a camel's-hair pencil dipped in a mixture of equal parts of brandy and aquafortis; then dry them by gentle pressure between sheets of thick soft paper. When the plant is thus far prepared, take the bulk of a nutmeg of gum-dragon, put this into a pint of pure cold water, and let it stand twenty-four hours, in which time it will be wholly dissolved; and then with a fine hair-pencil dipped in this liquor, daub over the posterior sides of the leaves, and lay them carefully down on half a sheet of white paper, and press them down. When the gum water is fixed, let the pressure and paper be removed, and the operation is complete. The leaves in this case retain their verdure, and the flowers usually preserve their natural colours. Some care, however, must be taken that the heat of the oven be not too great. When the flowers are thick and bulky, they should be reduced by paring away a portion of the back; after which, if any of them are wanting, their places may be supplied with some of supernumerary ones dried at the same time; and if any of them are faded, it will be better to substitute others in their stead. The leaves may be also disposed and mended in the same manner.

But the most valuable method of preserving living plants excluded from the atmosphere is by means of the Wardian case, for an account of which see Botany, vol. v., p. 107.

FLUDD, Robert (called in Latin De Fluctibus), an English physician and Rosicrucian philosopher, was the son of Sir Thomas Fludd, treasurer of war to Queen Elizabeth in France and the Low Countries, and was born at Milgate, Kent, in the year 1574. Blending the incomprehensible reveries of the Cabbalists and Paracelsians, he formed a new physical system, replete with mystery and absurdity, and believed in two universal principles, the northern or condensing, and the southern or rarefying power. Innumerable genii, as he conceived, presided over these powers, and committed the charge of diseases to legions of spirits collected from the four winds of heaven. In his estimation, a harmony subsisted between the macrocosm and the microcosm, or the world of nature and the world of man. It is impossible to enumerate all his fancies and whims, which, however absurd and extravagant, being supported by mysterious gravity and the semblance of erudition, attracted the notice of the philosophers of that age. Even Kepler himself thought the preposterous jargon of Fludd worthy of refutation, and Gassendi with the same view wrote his *Examen Philosophiæ Fluddianæ*, 1629.

Fludd wrote two books against Mersenne, the first entitled *Sophiæ cum Moria certamen, in quo lapis Lydius, a falso structore Patre Marino Mersenno monacho reprobatus, celeberrima voluminis sui Babylonici in Genesim figmenta accurate examinat*, Francfort, 1629, folio; and the second, *Summum Bonorum quod est verum Magiæ, Cabalæ, Alchymiæ, Fratrum Roseæ Crucis Verorum, Subjectum*, etc. 1629, folio. His other works were, 1. *Utriusque Cosmi, majoris et minoris, Technica Historia*, Appenheim, 1617, in 2 vols. folio; 2. *Tractatus Apologeticus integritatem Soc. de Rosea Cruce defendens*, Leyden, 1617; 3. *Monochordon Mundi symphoniacum, seu Replicatio ad Apologiam Joannis Kepleri*, Francfort, 1620; 4. *Anatomiæ Theatrum triplici effigie designatum*, ibid. 1623; 5. *Philosophia Sacra et vere Christiana, seu Meteorologia Cosmica*, ibid. 1626; 6. *Medicina Catholica, seu mysticum artis medicandi sacrarium*, ibid. 1626; 7. *Integrum Morborum mysterium*, ibid. 1631; 8. *De Morborum Signis*, ibid. 1631; 9. *Clavis Philosophiæ et Alchymiæ Fluddianæ*, ibid. 1633; 10. *Philosophia Mosaica*, Goudæ, 1638; and, 11. *Pathologia Dæmoniaca*, ibid. 1640.

FLUSHING, a town of Holland. See Vlisslingen.

FLUID, an appellation given to all bodies the particles of which yield, without separation, to the slightest pressure. See Hydrodynamics, and Pneumatics.

FLUTE, a wind-instrument of great antiquity, the older varieties of which are described by Père Mersenne in his *Harmonie Universelle*, Paris, 1636. The *Flute-à-bec* (disused for more than a century) was of various dimensions. The largest was a bass-flute, with a compass from F in the bass-clef, below the first line, up to D below the first line of the treble clef. The next, a tenor-flute, extended from B flat on the second line of the bass clef up to G on the second line of the treble clef; and each of these large flutes was sounded through a bent tube, like the S of a bassoon. The alto-flute reached from F on the fourth line of the bass clef up to D on the fourth line of the treble clef. The treble-flute extended from F in the first space of the treble clef up to F two octaves above. These two had *beaks*, like the bill of a cock. But all these flutes gave way, early in the last century, to the German flute, which, however, was then very imperfect in its intonation, having only one finger-key. By the addition of various finger-keys, for semitones, the German flute has been much improved in the present century. Like the fife, it is blown by an oval side-hole. It consists of four separable tubes, and has a compass of nearly three octaves, from the lowest C in the treble clef upwards. Smaller flutes of this kind are called third, fourth, and octave flutes. The octave flute is the *piccolo*, used in modern orchestras and in military music. See Music. (G. F. G.)

FLUX, a general term for any substance employed to promote the fusion of metals or minerals, as alkalies, borax, tartar, &c.; and in the large way, limestone, and fluor-spar.

FLUXIONS.

INTRODUCTION.

The calculus of fluxions, the most important addition that ever was made to the fabric of abstract science, was invented in the latter part of the seventeenth century. Considered as a purely intellectual speculation, it far transcends any theory that had been previously known in pure mathematics; and it is not less estimable by reason of its applicability to physical knowledge. By its powers as an instrument of analysis, the science of geometry has been exceedingly enlarged; and the elegant speculations of the ancient geometers now go but a little way into the vast field of knowledge which has been laid open by the fluxional calculus, the sublime discoveries of Apollonius and Archimedes being merely easy deductions from more extended theories. It has, further, rendered most efficient aid in the investigation of the laws of nature, more especially in establishing the true theory of the motions of the heavenly bodies, which, without its assistance, could not have attained its present high position in the scale of human knowledge.

It may easily be supposed that the invention of the calculus was not at once fully revealed to the world. Its principles being inherent in the nature of geometrical magnitude, they would of course be gradually disclosed with the advance of mathematical science.

As long as the geometers of antiquity confined their speculations to the comparison of figures bounded by straight lines, there was no difficulty. The axioms and the mental process of conceiving the magnitudes compared to be placed one upon another, was sufficient to establish the equality of triangles in the cases when these could be brought entirely to coincide. The principle of superposition might have been carried further in the elements, so as to prove the equality of parallelograms, which are the complements of those about the diameter of a parallelogram; also of parallelograms having equal bases and altitudes; and the equality of the square on the hypotenuse of a right angled triangle to the squares on its sides. In fact, the doctrines of plane geometry were sufficient to prove that any two equal rectilineal figures admit always of being decomposed into spaces, such that, corresponding to every space in one of the figures, there may be found a space exactly equal and similar to it in the other figure; so that in this way any two equal rectilineal figures, however dissimilar, may yet, by division, be brought to coincide.

The principle of superposition, which was sufficient for the comparison of rectilineal plane figures, one with another, could not, however, be extended to the comparison of rectilineal with curvilineal, or of curvilineal with curvilineal figures. In treating of these, the ancients found it necessary to introduce new notions and modes of demonstration into geometry; and the difficulty which occurred in reasoning about curvilineal figures gave rise to the method of exhaustions, the most refined and important of their geometrical theories.

The fundamental principle of the method of exhaustions is this very simple proposition, that the difference of any two unequal quantities, by which the greater exceeds the less, may be added to itself so often, as to exceed any finite quantity of the same kind. On this the geometers of antiquity founded their propositions concerning curvilineal figures. By its aid they found that polygons may be inscribed in circles, which shall differ from them by less than any assignable space; and hence they might infer that the circles have to each other the same ratio as similar polygons inscribed in them, namely, the squares of their diameters. Although in this way they could assure themselves of the truth of the propositions, yet as this kind of proof was of a looser nature than that by which they established their more elementary doctrines, they fortified it against all cavil by their usual mode of synthetic demonstration, proving that the square of the diameter of one circle was to that of another as the first circle to a space that was neither less nor greater than the second, and therefore exactly equal to it. By a like process they proved that a cone is one third of a cylinder of the same base and altitude; and from the demonstrations which they gave of these propositions, it might be concluded in general, that when two variable quantities which have a constant ratio approach to two determined quantities, so as to differ at last from them by less than any assignable space, the same constant ratio is also the ratio of the determined quantities, which are the limits of the variable quantities.

Introduction.

The cautious way in which the ancients proceeded in finally establishing the truth of their propositions concerning the proportions of solids, could be of very little use in their original discovery. Indeed we may reasonably suppose, that in the first instance they arrived at a knowledge of their truth by a much shorter road, probably in a way not very different from that followed by the earlier geometers in modern times, who have extended their theories. But whatever path they followed, it led them to some truths of the highest importance at the time they were first known. After ages of fruitless labour in attempting to square the circle, the fine discoveries of Archimedes, that the parabola was two thirds of its circumscribing parallelogram, and the sphere two thirds of its circumscribing cylinder, and its surface four times that of one of its great circles, must have been received by his contemporaries with high satisfaction.

In the beginning of the seventeenth century, the writings of Archimedes greatly engaged the attention of the principal cultivators of mathematical science, who soon seized the spirit of his method, which was altogether distinct from the unwieldy machinery of the ancient mode of synthetic demonstration. He had only considered such solids as could be generated by the revolution of conic sections about an axis, and he had not even exhausted all the cases of these. The celebrated Kepler greatly extended this theory, in a treatise which he composed on the mensuration of round solids. These he conceived to be formed by the revolution of the conic sections about any ordinate, or a tangent to the curve at the vertex, or, in short, about any line whatever within or without the curve. In this way he described about ninety new solids, and proposed them as problems for the consideration of his contemporaries; but of these he resolved only a few of the most simple. In this work he first introduced the name and notion of infinity into the language of geometry. He considered the circle as composed of an infinite number of triangles, having their vertex at the centre, and forming the circumference by their bases. The cone he regarded as composed of an infinite number of pyramids, resting on the infinitely small triangles which formed its circular base, and having their vertices at its vertex; and he supposed a cylinder of the same base and altitude as the cone to be made up of prisms having the

same bases and altitudes as those which composed the cone.

The bold extension which Kepler thus gave to the cautious language of geometry drew the attention of his contemporaries, some of whom eagerly followed in his steps. Cavalieri, a friend and disciple of Galileo, embodied the new views in his geometry of indivisibles, the theory of which he possessed in 1629, although it was not published until 1635. In this work, lines were considered as made up of points, surfaces as composed of lines, and solids as formed of surfaces. Cavalieri was exceedingly careful to verify his method, comparing his results with those which had been established by the ancient geometrical mode of demonstration; and, assured by their agreement, he ventured boldly in his new career. His principles were attacked, but he defended them by showing that they might be translated into those of Archimedes, from which they only differed in brevity of expression; his surfaces and lines being in fact merely the thin solids and small inscribed and circumscribed triangles of the ancient geometer, and their number being supposed so great that the difference between them and the figure about which they were described was less than any assignable quantity.

The new views proposed by Kepler were taken up in France by Roberval, who had carefully studied the writings of Archimedes, and formed a theory by which he could resolve problems concerning curvilineal figures. Instead of supposing lines to be made up of points, and surfaces of lines, as had been assumed by Cavalieri, he regarded a line as composed of an infinite number of infinitely short lines, a surface as composed of an infinite number of infinitely narrow surfaces, and so on; an assumption which at bottom was the same as that of the Italian geometer, but capable of being wrought up into a theory differing less from the spirit of the ancient geometry. Roberval concealed his views, employing them secretly as the means of invention in geometry, and expecting in this way to get the start of his contemporaries in reputation as a geometer. In the meanwhile the work of Cavalieri appeared and frustrated his selfish expectations.

The facility which the introduction of the notion of infinitely small quantities gave in the extension of geometry, induced all the mathematicians of that day to employ it in their researches. In the doctrine of curve lines it was applied to the theory of tangents by Roberval, Descartes, and Fermat, with great success. So very near had this last-mentioned geometer approached to the fluxional or differential calculus, that Laplace says he ought to be reputed its true inventor. Laplace was no doubt a great authority; but the facts on which he formed his opinion have always been generally known, and no one before him has attempted to reverse the decision of the age in which the calculus was invented. The justice of the decision has been subjected to a scrutiny by men of the highest powers of mind, who, differing in many of their opinions, have yet agreed in ascribing the invention to others.

The problem of drawing tangents to curves is indeed closely connected with the calculus, and at the period when this was about to be revealed that problem was much agitated, and successfully resolved by Slusius, Wallis, Barrow, and others. The writings and discoveries of Descartes exerted a most beneficial influence on the new geometry, particularly by his happy application of algebra to geometry. Before his time geometrical problems had been resolved by algebra, and a rich mine of discovery thereby opened. But he was the first who thought of applying algebraic formulæ to express the nature of curve lines; an invention of vast importance to both branches of mathematical science.

Another most important benefit that resulted from the new views which Descartes brought forward, was the notion of *variable quantity*. The early analysts distinguished quantities chiefly from the circumstance of their being known or unknown; and the main object of inquiry with them was to discover the chain of reasoning by which they might pass from the given quantities to the determination of those required. The view which Descartes took of geometrical magnitude brought the *relations* of quantities forward as a principal subject of contemplation. A new subject of discussion was brought into mathematical science, namely, the changes which take place in quantities connected by an invariable relation, when one of them is supposed to change its value, and pass from one state of magnitude to another. The science of geometry owes its elegance and the variety of its doctrines to the combined effect of magnitude and position, as they influence the subjects under consideration; and, in addition to these, the doctrine of curve lines has introduced a new element, namely, the property of varying in magnitude, as an attribute of quantity. This property of indefinitude, in respect of greatness, although it may appear a trivial affection of quantity, has, however, led to the most important consequences; for from this, combined with other principles, have sprung the fluxional calculus and other mathematical theories, which, originating in the ordinary conceptions of the human mind, have engaged the attention of men endowed with the highest powers of intellect for more than a century past.

In the progress of time the notions of infinite quantity introduced by Kepler, Cavalieri, and others, into mathematics, became familiar to geometers, who perceived the immense value of the improvement, and saw that, by due care in its application, there was no risk of its leading into error. Dr Wallis, in the year 1655, gave an admirable specimen of this new analysis in his *Arithmetic of Infinites;* a work which contained the first traces of the algebraic analysis applied to the quadrature of curvilineal spaces. Pursuing the views of Cavalieri, he reduced the problem of finding the areas of curves to the summation of the powers of an arithmetical series, consisting of an infinite number of terms, or rather the ratio of the mean of all the terms to the last term. He also showed by the same principles, that certain curve lines might be *rectified*, or that straight lines might be found to which they were exactly equal; a remark that was shortly afterwards verified by William Neil, a young mathematician of that period, who, at the age of nineteen, showed that the length of the semicubical parabola might be found in finite terms. This was the first curve that was rectified, and the second was the cycloid, a discovery due to Sir Christopher Wren.

Thus the principles of the fluxional calculus were at this period coming gradually into view. Their importance was seen and understood, and in substance, although without an appropriate notation, they were employed in extending the dominion of geometry; it might therefore be supposed that in the course of time they would have been gradually formed into a system, just in the way the science of algebra advanced from the rude form it had when first introduced into Italy, to that degree of compactness and perfection which it acquired by the successive improvements of Vieta, Harriot, and Descartes. But, in the case of the fluxional calculus, a happy combination of circumstances anticipated the slow operation of time. Newton and Leibnitz, two men endowed with the highest powers of mind, appeared nearly at the same time in the field of discovery. The genius of each shone with resplendent lustre, even amidst the blaze of intellect which enlightened the latter period of the seventeenth century, and which has rendered it for ever memorable in the annals of hu-

man knowledge. They both turned their attention to this branch of mathematical science, and, as is now generally admitted, each, independently of the other, collected the undigested principles into a system, and, by a powerful effort, performed at once what the united labour of ordinary minds would have hardly accomplished in a century.

In ascribing to each of these great men the full honour due to the merit of the invention of the calculus, it is proper to add, that this is a question which at one time divided the opinions of the learned world, and gave rise to a controversy which was agitated with great keenness for almost a whole century. There never could be any doubt as to Newton being the inventor of the calculus of fluxions. He has been acknowledged by all to have been the inventor, and the first inventor; but the question strongly contested has been, whether Leibnitz, without knowing what had been done by Newton, invented his differential calculus by the force of his own mind, or borrowed it from the fluxional calculus, with which at bottom it is identical.

In the course of this controversy it was clearly established by the British mathematicians, who almost to a man ranged themselves on the side of their illustrious countryman, that, as far back as the year 1669, Newton, then in his twenty-sixth year, and a fellow of Trinity College, communicated to Dr Barrow a tract, entitled *De Analysi per Æquationes Numero Terminorum Infinitas.* In this manuscript the method of fluxions was first indicated; and rules deduced from it given for the quadrature of curves, and various other matters to which the calculus is applicable, were distinctly specified. From this tract, which was sent by Dr Barrow to Collins, the secretary of the Royal Society, it is established beyond all doubt that Newton was then in full possession of his method; and indeed it is certain from other evidence that he must have had it as far back as 1666. The important discoveries made by Newton were communicated without reserve by the secretaries of the Royal Society to mathematicians on the Continent, as well as to those in Britain. In this way it might be generally known that Newton possessed a most valuable instrument of research, by which he had been led to these results, although its nature was too obscurely indicated to give any assistance in divining its precise form.

Leibnitz appears to have been later than Newton in beginning his career of discovery in the mathematics. In the year 1672, being then in London, he communicated to some members of the Royal Society what he supposed to be discoveries relating to the differences of numbers. It was, however, shown to him that the same subject had been discussed long before, by Mouton, a French geometer. He then appears for the first time to have turned his attention to infinite series. Afterwards, on his return to Germany in 1674, he announced to Mr Oldenburgh, then secretary of the Royal Society of London, that he possessed very general analytical methods, by which he had found theorems of great importance relating to the quadrature of the circle, by means of series. In answer, the secretary informed him that Newton and James Gregory had also discovered methods which gave the quadrature of curves, and which extended to the circle.

In the year 1676 Newton addressed a letter to the secretary of the Royal Society, which was made known to Leibnitz. This was the first direct communication between these two great men. It contained the binomial theorem, which Newton had known in the year 1669, and a variety of other matters relating to infinite series and quadratures; but nothing directly relating to the method of fluxions. At this time Newton entertained no jealousy of Leibnitz, for he speaks of him in the letter with great respect. In a second letter Newton explained at his request the way in which he had found the binomial theorem, and he adverted also to his own calculus, explaining the purposes to which it could be applied, but concealing its nature under the form of an anagram of transposed letters, which was expressed thus, 6*accdae*13*eff*713*l*9*n*4*o* 49*rr*4*s*9*t*12*vx*. It is not easy to see what certain information Leibnitz could draw from this assemblage of characters; yet such was the effect of national prejudice in biassing the minds of the British mathematicians, that Raphson, in his *History of Fluxions*, a work dedicated to the Royal Society of London, expressly asserts that Leibnitz deciphered the anagram, and found it to be this sentence, *Data equatione fluentes quotcunque quantitates involvente invenire fluxiones, et vice versa.* "Having any given equation involving never so many flowing quantities, to find the fluxions, and *vice versa.*" We believe there was not the least ground for this assertion; and from such a specimen of want of candour, it is easy to infer that there was very little chance of Leibnitz getting justice done him by the English mathematicians.

In the month of June 1677 Leibnitz sent to Mr Oldenburgh, to be communicated to Newton, a letter containing the first essays of a method which extended to all that could be done by that of Newton. The death of Oldenburgh, which happened soon afterwards, put an end to the correspondence, and it was not until the year 1684 that Leibnitz made his discovery public, it being then inserted in the Leipsic Acts; so that whilst Newton's claim to the priority of the discovery must be admitted by all, it is not less certain that Leibnitz was the first to give the full benefit of the calculus to the world; for Newton's Method of Fluxions only became generally known in the year 1687, by the publication of his *Philosophiæ Naturalis Principia.*

It is certain that Leibnitz enjoyed unchallenged for fifteen years the honour of being the inventor of his calculus; even Newton himself rendered him that justice in the first edition of his immortal work. Subsequently, however, a foreign mathematician, Fatio de Duillier, piqued, it is said, by having been omitted in an enumeration of eminent geometers by Leibnitz, declared, in a treatise on the line of shortest descent, printed at London in 1699, that he was obliged by the undeniable evidence of things to acknowledge Newton not only as the first, but as by many years the first inventor of this calculus; from whom, whether Leibnitz, the second inventor, borrowed any thing or not, he would rather they who had seen Newton's letters and other manuscripts should judge than himself.

The insinuation contained in this passage of Fatio's book could not but be very offensive to Leibnitz, who inserted an animated reply in the Leipsic Acts of 1700, and complained to the Royal Society of London of the injustice done him; and here the affair rested for a time: but it was revived some years afterwards. When Newton's treatise on the quadrature of curves, and his enumeration of lines of the third order, was published, the Leipsic journalists gave an unfavourable review of the work. Amongst other things, after a brief exposition of the nature of fluxions, they added, that Newton uses and has always used fluxions for the differences of Leibnitz, just as Fabri had substituted in his synopsis of geometry motion instead of the indivisibles of Cavalieri. This most unjust accusation excited great indignation in the minds of the British mathematicians, one of whom, Keill, Savilian professor of astronomy at Oxford, in a paper inserted in the *Philosophical Transactions* of the year 1708, affirmed that Newton was the first inventor of the calculus, and that Leibnitz, in publishing it in the Leipsic Acts, had merely changed the name and the notation. Leibnitz, thus directly charg-

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ed with having taken his calculus from that of Newton, addressed a letter to Mr, afterwards Sir Hans Sloane, the secretary of the Royal Society, in which he required that Keill should retract his accusation. Keill however refused to do this, and in answer addressed a letter to the secretary, in which he professed to show, not only that Newton had preceded Leibnitz in the invention, but that he had given so many indications of his calculus that its nature might easily be understood by any man of ordinary understanding. This letter was sent to Leibnitz, who addressed a second letter to the Royal Society, requiring that they should stop these reproaches of Keill, saying that he was too young a man to know what had passed between him and Newton.

The society, thus appealed to as a judge, appointed a committee to examine the old letters, papers, and documents which had passed between the mathematicians on the subject. The report of this committee does not appear altogether satisfactory. "We take the proper question to be," say the reporters, "not who invented this or that method, but who was the first inventor of the method; and we believe those who have reputed Leibnitz the first inventor, knew little or nothing of the correspondence between Mr Collins and Mr Oldenburg long before, nor of Mr Newton having that method about fifteen years before Mr Leibnitz began to publish his in the *Acta Eruditorum* of Leipsic; for which reason we reckon Mr Newton the first inventor, and are of opinion that Mr Keill, in asserting the same, has been nowise injurious to Mr Leibnitz." This declares nothing on the only point about which there could be any doubt, namely, whether Leibnitz had formed his calculus entirely by the power of his own genius, or had availed himself of a knowledge of Newton's invention. The judgment satisfied neither party. Keill wished to establish against Leibnitz the charge of plagiarism, but was disappointed; and Leibnitz found in the decision grounds of complaint against the Royal Society. In a communication to the Abbé Conti, a Venetian nobleman and a common friend of his and Newton, then in England, he accused the English nation of desiring to be considered as almost the only inventors. He said it did not appear, as had been well observed by Bernoulli, that Newton possessed before him the infinitesimal characteristic and algorithm, although it would have been easy to have found it if he had been so disposed, just as it would have been easy for Apollonius to have discovered the theory of curve lines of Descartes. He complained that his opponents had attacked his candour by forced and unfounded interpretations of his words. The question was the calculus of differences, and his opponents made it turn entirely upon series, where Newton had no difficulty in going before him. He maintained that he had found for himself a general method for series, and that he had no need of Newton's method of extractions. There were other grounds of complaint, such as, that only extracts from letters had been given in the *Commercium Epistolicum*, whereas the entire letters should have been published. Throughout the whole, which is a postscript to a letter, he manifests much chagrin; and he concludes with proposing this problem, intended, he says, to feel the pulse of the English analysts: To find a line which shall cut perpendicularly all curves of a determinate species, and of the same kind; for example, all hyperbolas, which shall have the same vertex and centre. This he desires the abbé to propose as from himself, or a friend.

In the abbé's reply to this letter he informed Leibnitz that he had delayed writing until he could at the same time send the answer which Newton had given to his postscript. He tells him that he had read the *Commercium Epistolicum*, and the originals of the letters which it contained, and, on the whole, he inferred that, setting aside matters foreign to the dispute, the only question at issue was, whether Newton had found the Calculus of Infinitesimals, or Fluxions, before, or after him? The abbé says, you published it first, it is true; but you admit that Newton allowed much to transpire in the letters which he wrote to Oldenburgh and others. This has been proved at length in the *Commercium* and its extract; what is your answer? This is what the public requires, to form a correct opinion on the matter. The abbé further informs Leibnitz that his friends believe he ought to give an answer, if not to Keill, at least to Newton himself, who, in the letter which the abbé had received from him to be communicated to Leibnitz, had challenged him in express terms. In a spirit of friendship and good sense, he further adds, that he wishes to see a good understanding between them, that the public will profit but little by their disputes, and that the additions to knowledge which they prevent are a pure loss to posterity. He moreover tells him that the king, George I., had desired to be informed of all that had passed between Newton and him. From this we may judge what an interest was excited in the public mind by a dispute which, even at this day, few could perfectly understand. The answer which Leibnitz gave to the abbé's friendly advice was, that he had put his letters, and Newton's, with his own answers to them, into the hands of Mr Remond at Paris, with a view to have a neutral and impartial opinion as to the matters in dispute. The whole were then to be submitted to the Abbé Varignon and other members of the Royal Academy of Sciences, and afterwards sent to England. In his answers he disavowed the sense which the English mathematicians had extracted from the assertion of the Leipsic journalists, namely, that Newton employed and always had employed fluxions for the differentials of Leibnitz, which they understood to mean that Newton had availed himself of Leibnitz's method, only substituting fluxions for differentials. It was from this passage that the English had declared Leibnitz to be the aggressor, in having abetted an attack of Newton; but Leibnitz declared the English interpretation to be full of malignity towards him, and that the sentence in the *Leipsic Acts* (*Pro differentiis Leibnitianis D. Newtonus adhibet semperque adhibuit fluxiones*), meant that Newton had employed fluxions after having seen his differences, and also before he had seen them.

We believe enough has been detailed to show that, besides a desire to arrive at truth, there was infused into this controversy the jealousy of two rivals for the glory of a great discovery; and, in addition, the spirit of partizanship of their respective admirers, and that natural feeling which induces men of different countries to exalt their own nation, although sometimes at the expense of their neighbours. It is not wonderful, then, that at the time this controversy was at its height, men were greatly divided in their opinions.

It is now impossible to obtain absolute certainty as to the question, whether Leibnitz derived any aid from the discoveries previously made by Newton, which, to a certain extent, were made known to the scientific world. It may therefore be some satisfaction, in the want of perfect evidence, to have the judgment of Montucla, the historian of the mathematics, on this subject. "In regard to the principle of fluxions," says he, "there are only three places of the *Commercium Epistolicum* which treat of it with sufficient clearness to prove that Newton had found it before Leibnitz, but I believe too obscurely to take from him the merit of the discovery. One of these is a letter from Newton to Oldenburgh, who had remarked to him that Slusius and Gregory had found a very

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simple method of tangents. Newton answered that he conjectured what it was, and he gave an example, which is in effect the same thing as these two geometers had found. He added that it was but a particular case, or rather a corollary to a method much more general, by which tangents to all sorts of curves, whether geometrical or mechanical, might be found without laborious calculation. He repeated the same thing, without explaining himself further, in his second letter, which has been already mentioned, and he concealed the principle under transposed letters. The only writing in which Newton had allowed any thing of his method to transpire is his *Analysis per Equationes numero Terminorum infinitas.* He there briefly and obscurely reveals his principle of fluxions. It cannot be denied that the principle and method were there indicated; but it is not certain that Leibnitz had ever seen the passage. His adversaries have never said that it had been communicated to him by letter; they have merely thrown out a suspicion that Collins might have communicated it to him in his second journey to London. Indeed the suspicion is not altogether void of probability, inasmuch as Leibnitz admitted that in his interview with the secretary he had seen a part of his epistolary correspondence. I believe, however, that it would be rash to pronounce upon this. There might have been grounds for suspicion if Leibnitz had merely given a few essays of his new calculus; but when we consider the improvements he made, as appears by the number of pieces he contributed to the *Leipsic Acts,* it seems probable that he owed his calculus to his own genius, and his efforts to divine the nature of a method by which Newton had made so many fine discoveries. This is the more probable, as from the method of tangents of Barrow to the differential calculus, the step is not too great to have been made by a power of mind of which Leibnitz had given so many proofs."

If it had been true, as the British mathematicians alleged, that Leibnitz had taken his calculus from that of Newton, it would have been a very remarkable circumstance that such a long period should have elapsed between his first putting forth his pretensions to the honour of the invention, and the denial of Newton and his friends. This is a thing uncommon in the history of contested claims to discovery, when both the claimants are alive and all the facts known. It is also remarkable that Newton, while in the prime of life, did not of his own accord bring forward a charge of plagiarism against his contemporary. On the contrary, in the first edition of his *Principia,* which appeared in 1687, he expressly admitted Leibnitz's claim; and this admission is found even in the edition of the *Principia* published in 1713. It is now well known, that before the period of the controversy between Newton and Leibnitz, the mind of the former had at one time been in a state which rendered him unfit to draw correct conclusions from the ordinary incidents of life; witness his letters to Mr Pepys and Mr Locke in September 1693 (Brewster's *Life of Newton*). At this time he seems to have laboured under great bodily indisposition, from which he afterwards in appearance recovered; indeed it may be doubted whether his temper was so equal and mild in the latter period of his life as has been represented by his biographers. A collection of letters which passed between Flamsteed the astronomer and Abraham Sharp the celebrated calculator, which have lately come into the possession of the Astronomical Society of London, prove that Newton, in conjunction with Halley, opposed Flamsteed in the publication of his *Historia Cœlestis,* a work of the highest merit, and the result of the labour of his life, with a pertinacity of purpose which is by no means an amiable trait in his character. It is certain that Newton entertained towards Leibnitz a very different feeling at one period of his life, from that which he in the end evinced. In the edition of the *Principia* 1713, and those which preceded it, he says, " Ten years ago, in a correspondence with Mr Leibnitz, I informed him that I had a method of determining maxima and minima, of drawing tangents, and resolving similar problems, which applied alike to rational and irrational terms, but concealed it under transposed letters. He answered that he had found a like method, which he communicated, and which differed from mine only in the terms and the signs, and in the way of conceiving quantities to be generated." This concession was liberal, and worthy of Newton. However, in the edition of 1726, he retracted this act of justice, having struck out the passage, as Montucla assures us, with his own hand. The historian of the mathematics, however, finds an excuse for this harshness in the treatment which Newton had received from Leibnitz's friends.

The circumstance of the calculus having had two distinct origins, had the inconvenient effect of giving it two different forms and names. Newton at different times used different notations before he finally adopted that which has been followed by the English mathematicians. Leibnitz and his followers employed one somewhat different; and each sect pertinaciously adhered to the example set by its leader. There was a still greater difference in the view which each party took of quantity, and the way in which it may be generated. Newton conceived geometrical magnitudes to be generated by continued motion, a line by a point in motion, a surface by a moving line, a solid by a moving surface, an angle by a line turning about a point, and so on. It is evident, that by assuming geometrical quantities as the representatives of time, force, and whatever can be expressed by number, these can be conceived to increase or decrease according to the same laws as their geometrical representatives. His calculus therefore consisted of two parts:

1*st,* Supposing two quantities to have a given relation to each other (for example, the one to be always equal to the square of the other), and the rate of increase of one of them at any instant of time to be known; to find the rate of increase of the other at the same instant. These rates of increase were called the *fluxions* of the quantities; and the rules for their determination constituted the *direct method of fluxions.*

2*d,* The second part was the reverse problem, in which the relation between the rates of increase of two quantities which depended the one on the other, being given, it was required to discover the relation of the quantities. This was the inverse method.

Leibnitz at first supposed quantity to increase by the addition of some indefinite portion of a quantity of the same kind, and his *differentials* were quantities proportional to the instantaneous changes in the greatness of the quantities thus generated. He afterwards found it shorter to introduce directly these instantaneous changes into his calculus under the name of infinitely little differences (*infiniment petites*). These however he did not regard as absolute *zeros,* but only as not comparable to finite magnitudes. His calculus had, like Newton's, two parts, the *differential calculus,* which gave rules for deducing the relation of the differentials of quantities from that of the quantities themselves, and the *integral calculus,* which resolved the reverse problem, or discovered the relation of the quantities when the relation of their differentials was known. This corresponded to the inverse method of fluxions, as the differential calculus corresponded to the direct method.

There is this distinction, then, between the two methods:

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Newton's fluxions are any finite quantities which have to each other the ratio of the velocities, or degree of quickness with which the quantities are generated. The differentials of Leibnitz are infinitely small quantities, a creation of the mind more removed from ordinary apprehension than the finite representatives of fluxions. This distinction has often been urged in favour of the superiority of Newton's calculus. On the other hand, Newton has introduced time into his calculus. Now this is an element foreign to geometry, and belonging to mechanics, a quite distinct branch of science. The metaphysical distinctions between the two forms of the calculus have had but little influence on its progress. Whichever of the two forms is chosen, the rules are the same; and so also are the difficulties to be overcome.

Some time elapsed before the newly invented calculus was actively employed. At length Leibnitz, to rouse the attention of geometers, proposed in 1687 this problem: To determine the curve along which a heavy body must descend, so as to approach by equal distances in equal times to a horizontal plane. Huygens was the first to resolve the problem. He showed what was the nature of the curve; but he did not give his demonstration. James Bernoulli also resolved the problem by the differential calculus, and published his analysis in the *Leipsic Acts*. His younger brother John united himself in a close friendship with Leibnitz, and continued throughout life his coadjutor and staunch defender. He made the calculus known in France, where he resided for a time, and gave lessons to the Marquis de l'Hôpital. Part of these form the *Analyse des infiniment Petits*, a work which bears the name of the marquis, with but a slight acknowledgment in the preface of the share which his preceptor had in its composition. Indeed it was almost entirely his; and of this injury Bernoulli complained justly, but privately, in his correspondence with Leibnitz. The remaining lessons, which teach the integral calculus, are given in the collection of Bernoulli's works, published in 1742. The whole form an excellent exposition of the principles of the calculus, and contain some of its finest applications.

The continental mathematicians who were remarkable for their skill in the differential calculus were at first few in number. They might be nearly all included in the names of Leibnitz himself, James and John Bernoulli, De l'Hôpital, and Varignon. They were, however, remarkably active, particularly the Bernoullis, whose writings have contributed powerfully to its advancement.

The inventor of the fluxional calculus seems to have taken but little interest in its extension. His treatise on quadratures did not appear till 1706; and his work on fluxions was not published in his life time, but appeared in 1736, nine years after his death. He had however fully availed himself of its power in the composition of his *Principia*, without revealing to the full extent the nature of the instrument with which he wrought, but establishing the truth of his propositions by synthetic demonstration, after the manner of the ancient geometers. Probably this was done in deference to the taste of that time; for a contemporary writer, Hermann, in following his example in the composition of his *Phoronomia*, assigned to Leibnitz as a reason, that the geometrical method was likely to be better understood than the analytical in Italy. This way of proceeding is now, however, disused by the best writers, and replaced by the more legitimate and undisguised use of the calculus.

The extensive views which the new calculus opened up, afforded the means of resolving problems which had baffled the skill of the earlier mathematicians, and suggested many new ones, which without its aid would have been quite intractable. The cycloid and the catenary, curves which had eluded the penetrating mind of Galileo, were more fully comprehended; many new ones were suggested, and the cultivators of the calculus challenged each other to an investigation of their properties. There is an elegant class of problems which relate to the greatest and least values of quantities. Some of these, called problems of *maxima* and *minima*, can be resolved by the ordinary geometry and algebra; but there is a class which lies beyond the dominion of these, and to it belongs the solid of least resistance, the curve of swiftest descent, and, in general, the problems called *isoperimetrical*, one of the simplest of which is to find the nature of the line which, being given in length, shall comprehend the greatest possible space. These formed the subject of a warm but honourable contest between the two Bernoullis, brothers; and their investigation laid the foundations of that branch of the calculus, the highest, which has been formed into a theory by the labours of Euler and Lagrange, under the name of the *Calculus of Variations.*

Among the early cultivators of the calculus in Britain we may reckon Cotes, the friend of Newton, who died at the early age of thirty-four (his *Harmonia Mensurarum*, and other writings, indicate a genius of the highest order), De Moivre, Taylor, Craig, David Gregory, and Stirling. It must, however, be confessed, that the continental school in the course of time advanced before that of Britain, as well in the number of its disciples, as in their high mathematical genius and the importance of their discoveries. John Bernoulli had two sons, Nicolas and Daniel, who rivalled their father's skill in the applications of the calculus; and these had as condisciples Hermann and Euler. This last mathematician has carried the subject to a point of perfection far beyond what it had attained in the hands of those that had gone before him.

Amongst the means by which the improvement of the calculus has been promoted, we may reckon the problems which passed between the British and continental mathematicians as challenges to each other, in answering which Newton himself condescended sometimes to enter the lists. The doctrine of infinite series, a branch of the mathematics of English origin, gives powerful aid to the calculus in its greatest difficulties; but, legitimately, its assistance ought not to be called in if the problem admit of being resolved in finite terms. The English sometimes failed in the observance of this most proper condition of a good solution, and thus gave rise to reproaches from their opponents, which in at least one instance were not unjustly incurred by Newton himself. In the course of this warfare, Keill, the champion of the English, proposed as a challenge to John Bernoulli, to determine the nature of the curve which a projectile describes in a medium resisting as the square of the velocity. Bernoulli soon resolved the problem, not only in the case proposed, but also when the resistance was as any power whatever of the velocity. He then proposed to put his solution into the hands of some confidential person in London, provided that Keill would deliver his solution to the same person. Keill, however, had upon trial not been able to resolve the problem, and therefore preserved a profound silence, and made himself, by his boasting and failure, quite ridiculous. The triumph of Bernoulli was complete, and he did not miss the opportunity of bestowing severe castigation on his humbled adversary, recollecting, we may suppose, the treatment which his deceased and lamented friend Leibnitz had received from him and his friends.

As another proof of the spirit and rivalry of the supporters of the two analytical theories, we may mention that Brooke Taylor proposed a problem in the integral calculus to all geometers not English, and sent it to Mr Montmort to be communicated to the foreign geometers.

Notwithstanding the general terms of the challenge, it was well understood to be particularly aimed at John Bernoulli, who in return offered to wager fifty Louis that he would resolve the problem, and to stake fifty more that he would propose a problem which he himself could resolve, but which Taylor could not. The English mathematician did not think it prudent to accept the offered condition. Indeed it was a complaint against the English geometers, that although they made no scruple of trying to puzzle foreigners with difficulties, they rarely responded to the counter challenges proposed to themselves.

Perhaps there never was a considerable invention or discovery which had not to encounter opposition; sometimes from the slowness with which the human mind yields to the force of truth when opposed to long-received opinions, and sometimes from less excusable causes, such as mistaken or interested views, or mere jealousy excited by the fame of the inventor. The new calculus had in the very outset its opponents, such as the Abbé de Catelan, a zealous Cartesian, who declared that it would be better to extend the principles of the Cartesian geometry than to seek for new methods; and this was said in the preface of a book composed on the principles, somewhat disguised, of the very calculus of which he was an opponent. It had another adversary in Nieuwentiit, a man who had written some tolerable works on morality and religion, but who had but small pretensions to be regarded as a geometer. Catelan was satisfactorily answered by De l'Hôpital, as was Nieuwentiit by Leibnitz, and afterwards by Bernoulli and Hermann, who proved that this adversary of the calculus really did not know what he opposed.

The calculus had a more formidable enemy in M. Rolle, a skilful algebraist and indefatigable calculator, but a man full of confidence in his own notions, rash in forming his opinions, and jealous of the inventions of others. He attacked the certainty of its principles, and he attempted to show that its conclusions were at variance with those obtained by methods previously known, which were acknowledged to be correct. His attack was repelled by Varignon, who completely obviated the objections to the truth of the principles, and further showed that the supposed discrepancy between its conclusions and those obtained by other methods, were mistakes he had committed from haste and inadvertence. These disputes occupied the French Academy a considerable part of the year 1701. The members were chiefly geometers considerably advanced in years, who had been long accustomed to other methods, and were therefore not much disposed to receive new doctrines. Some took no part in the dispute, yet were not sorry to see a storm raised against a theory for which they had no great liking, and took no means to allay it; others, more under the influence of their passions and prejudices, yielded to these, and declared open war against it. In this state of things the best course was supposed to be that of hearing all which could be said for and against the calculus. The academy was long involved in the dispute. Rolle brought forward objection upon objection; and although Varignon continually obviated them, yet the former always claimed the victory. In the end the dispute degenerated into a real quarrel, and commissioners were appointed to decide on it. These were Père Gouye, MM. Cassini and de la Hire, who, however, pronounced no judgment; but the public opinion, or at least the opinion of geometers, was in favour of Varignon. The first controversy thus ended, or at least was suspended, for want of a decision from the commission; but Rolle, the champion of the opponent of the calculus, soon renewed hostilities. Its defence was next taken up by M. Saurin. The ground of attack was the indefinite form which the calculus gives for the subtangent of a curve at the point where two branches intersect each other, and which in this case is expressed by the fraction $\frac{0}{0}$.

Saurin's answer was satisfactory; but Rolle, intrenched in masses of calculation, obstinately maintained the combat. The academy was again appealed to. The Abbé Bignon, who conducted its affairs, undertook to decide the controversy, with the assistance of MM. Gallois and De la Hire, two judges by no means favourable to Saurin. They gave no absolute judgment; but recommended to Rolle to conform more strictly to the rules of the academy, and to Saurin to forgive the proceedings of his adversary. Rolle suffered in the estimation of competent judges; he, however, afterwards did justice to the calculus, by acknowledging that he had done wrong in opposing it, and admitting that he had been urged forward by the instigation of malevolent persons, one of whom was the Abbé Gallois; and his demise in 1707 accordingly put an end to the controversy.

In England the Newtonian calculus had to sustain an attack on its principles from a writer of first-rate talents, Berkeley, bishop of Cloyne. The circumstances which led to it are curious. Mr Addison had given the bishop an account of the behaviour of their common friend, Dr Garth, in his last illness, which was highly unpleasing to these two advocates of revealed religion; for when Addison began to discourse with Garth on a future state, "Surely," said the latter, "I have no reason to believe these trifles, when my friend Dr Halley, who has dealt so much in demonstration, has assured me that the doctrines of Christianity are incomprehensible, and religion itself an imposture." The bishop therefore took up arms against Halley, and in the year 1734 addressed to him, as an infidel, a discourse called The Analyst, the object of which was to prove that mathematicians acted inconsistently in objecting to mysteries in faith, seeing that they did not hesitate to admit much greater mysteries, and even falsehoods, in their own science; and he chose the principles of the doctrine of Fluxions, as laid down by Newton and adopted by his followers, to prove the truth of his proposition. It may be supposed that so able a writer would not fail to make an impression on the public mind. But the mathematicians were not slow in coming forward in defence of the doctrines of their chief. In the same year came out a tract with this title: "Geometry No Friend to Infidelity, or a Defence of Sir I. Newton and the British Mathematicians, by Philalethes Cantabrigiensis," supposed to be Dr Jurin. As usual the attack was renewed, and again repelled by the same hand. Other defences of Newton appeared, one of the best of which was from the pen of Benjamin Robins; it was entitled A Discourse concerning the Nature and Certainty of Sir Isaac Newton's Method of Fluxions, and of Prime and Ultimate Ratios. But the most important result of this controversy was A Treatise on Fluxions from the pen of Colin Maclaurin, professor of mathematics in the university of Edinburgh, printed in 1742. This defence of the principles of Newton's views, expressly intended to obviate all objections, is quite satisfactory. The treatise is indeed considerably prolix; but this was a consequence of the circumstances in which it was composed. It however contains a great deal more than a mere theory of fluxions. We have in it some of the finest applications of analysis to the principal problems which had been agitated amongst geometers from the invention of the calculus to the time in which the work appeared.

By the middle of the century the calculus proceeded with a rapid march of improvement. Euler in 1744 greatly enriched it by his solution of the Isoperimetric Problem (*Solutio problematis isoperimetrici latissimo sensu accepti*), a theory which he afterwards wrought up into the Calculus

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of Variations, and which has been still further improved by Lagrange. Brooke Taylor, by his *Methodus Incrementorum*, had extended the foundations, and even proceeded a great way in the structure, of a kindred calculus, that of finite differences. Stirling had followed in the same path in his *Methodus Differentialis;* and Euler had opened a new field for discovery in the calculus of partial differences, in which D'Alembert followed his steps, and carried the subject further. The same period abounded in good writers. In this country Demoivre, Simpson, Landen, and Waring, stand among the foremost in the list for the originality of their views; on the continent Ricatti, Clairaut, Fontaine, and others, followed in the train of Euler and the Bernoullis.

It is a curious fact in the history of mathematics, that there are instances of ladies who have applied their talents to its study and improvement with much success. Hypatia, the daughter of the ancient geometer Theon, is one notable instance. Unfortunately we have no vestiges of her writings by which we might form an estimate of her proficiency in a science which at first sight seems not to have many attractions for the female mind. We have another instance in an Italian lady, Maria Gaetana Agnesi, who was actually professor of mathematics in the University of Bologna in the year 1748; and how well she was qualified for the office appears from her Analytical Institutions, a work of great excellence on algebra, the theory of curve lines, and the differential calculus, composed for the instruction of the youth of Italy. This work is so excellent, that Bossut, a French mathematician of great eminence, translated the part on the differential calculus into French, and incorporated it with his Course of Mathematics, as the best treatise he could find on the subject. There is also an English translation by the Rev. John Colson, Lucasian professor of mathematics in the university of Cambridge. Her countryman Frisi, a most competent judge, mentions her in enumerating the mathematicians of Italy, and bestows great praise on her work, calling it *opus nitidissimum, ingeniosissimum, et maximum certe opus quod hactenus ex feminæ alicujus calamo prodierit.* At the present time we have another admirable instance of a lady who has surmounted the difficulties of the calculus. Mrs Somerville, in her work entitled *Mechanism of the Heavens*, London, 1831, has enriched English literature with a treatise on physical astronomy, in which the different branches of the calculus are combined with the most refined theories of mechanics. Her book does her infinite credit, and indeed is highly honourable to the whole female sex.

Geometers have differed in opinion as to the best way of working up the principles of the calculus into a system. Newton, as has already been stated, employed the theory of motion as the means of connecting its doctrines with the principles of the ordinary algebraic analysis. Leibnitz, again, with the same view, conceived quantity as passing from one degree of magnitude to another by the continual accretion of infinitely small parts. The mind finds no great difficulty in distinctly apprehending the subject in its simplest state either way. Objections have, however, been taken to both, and attempts made to substitute a better. Euler considered the infinitely small quantities of Leibnitz as absolute zeros, that have to each other ratios derived from those of the vanishing quantities which they replace. D'Alembert proposed to make the basis of the calculus the consideration of the ratios of the limits of the quantities. An English mathematician, Landen, has substituted for the Newtonian method of fluxions another purely analytical. His views are contained in a work entitled The Residual Analysis, a new branch of the Algebraic Art, by John Landen, 1764. Lastly, Lagrange, in the Memoirs of the Berlin Academy for 1772, proposed to make the calculus altogether independent of the consideration of infinity, and to rest on principles purely analytical, thus connecting it with the doctrines of the ordinary algebra. He has since realised and extended his views in his *Théorie des Fonctions Analytiques*, also in his *Leçons sur les Calcul des Fonctions;* works which, from their excellence and the celebrity of their author, have formed a new era in the history of the calculus.

The twofold origin of the calculus, besides placing its principles on different foundations, gave it also two different forms of notation; and in this state it continued during the whole of the eighteenth century, to the great inconvenience of mathematical students, and, we may add, to the hindrance of the progress of science. A change, however, has taken place within the last twenty years; during that period some British geometers, imbued with the mathematics of the continent, adopted also its notation in preference to that of the followers of Newton, and employed it publicly in their researches. This spirit of innovation in time took possession of the minds of the junior members of the university of Cambridge, and now we may say that it has completely supplanted the native notation. We have retained the name of Fluxions, because, from the changes which have taken place in the way of treating the subject since the days of Leibnitz and Newton, it seems to be as proper as the term differential. It is otherwise with the notation. This is consecrated by its having been employed in the writings of Euler, D'Alembert, Lagrange, and other great masters in mathematical science; and besides, it has advantages over the other in point of symmetry and compactness, and the established reputation of a whole century of useful service. It is true, the late illustrious Lagrange laid it aside in his attempt above mentioned to new-model the calculus; but subsequent writers, in extracting what was excellent from his works, have in general invested his views with the ordinary notation of the continent. In the following treatise we shall conform to this beneficial alteration.

Writers on the Infinitesimal Calculus, before the Invention of the Method of Fluxions.

Kepler, Nova Stereometria Doliorum Vinariorum.............. 1615
Cavalieri, Geometria Indivisibilium.............................. 1635
——— Exercitationes Geometricæ Sex.............. 1647
Roberval, Traité des Indivisibles. Mém. de l'Acad. des Sciences 1666
Descartes, in his Letters and Geometry, book 2d, and his mathematical works.. 1637
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Tabiescen, Principia atque Historia Calculi Differ. et Integ. nec non Methodi Fluxionum ... 1793
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—— Théorie des Fonctions Analytiques ... 1797
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Traité Elémentaire de la Theorie des Fonctions et du Calcul Infinitésimal par M. A. A. Cournot, in 2 volumes ... 1841
De Morgan's Differential and Intégral Calculus ... 1842
Leçons de Calcul Différentiel et de Calcul Intégral, par M. l'Abbe Moigno, 2 vols ... 1840–4
Hymer's Intégral Calculus ... 1844
Exposé Elémentaire de la Theorie des Intégrals Définies par A. Meyer 1851, in the Memoires of the Royal Society of Science at Liège; and many valuable papers on the subject in the Journal de L'Ecole Royale Polytechnique, and in the Journal de Mathématiques Pures et Appliquées par Joseph Lionville.
Hall's Differential and Integral Calculus, fifth edition ... 1852
Todhunter's Differential and Integral Calculus ... 1852
Price's Infinitesimal Calculus, in 2 vols ... 1854
The last two are the most perfect treatises on the subject in the English language, and Price's abounds in lucid and elegant illustrations and applications of the subject.
Carmichael's Treatise on the Calculus of Operations, designed to facilitate the processes of the Differential and Integral Calculus, and the Calculus of Finite Differences; London 1855
Besides the above, many valuable papers have appeared on the subject in the Mathematician, and in the Cambridge and Dublin Mathematical Journals.
Levy's Differential and Integral Calculus in the Encyclopædia Metropolitana.

The preceding catalogue contains the names of the principal improvers and cultivators of the calculus, from its first invention to the present time (1855). However, it does not contain all their writings; to have enumerated these would have extended the catalogue to too great a length. Almost all the improvements of the calculus were first given in the form of academical memoirs, from which they have been drawn, and incorporated into the systems that have from time to time been published. The great repertories in which it is contained are the writings of Newton, Cotes, Demoivre, the Bernouillis, Maclaurin, Simpson, Euler, D'Alembert, Lagrange, Legendre, La Place, Monge, Poisson, Gauss, Ampère, Ivory, &c. From these have been constructed the treatises of De l'Hôpital, Bougainville, Le Seur and Jacquier, Cousin, and others, which were the most complete at the different periods when they appeared. At this time the most extensive treatise is the second edition of Lacroix, which came out between 1810 and 1819. In the present century there have been published in France treatises by Garnier, Du Bourguet, Bouchariat, Cauchy, and others which we have not seen. In Britain, we have had treatises by Woodhouse, Dealtry, Lardner, Jephson, Young, Thomson, and others. The university of Cambridge, long infertile, now teems with treatises on the subject. There are, besides, treatises on the calculus in courses of mathematics, such as the Elementi d'Algebra of Paoli, the Cours des Mathematiques of Bezout, a like work by Francœur, and a Course of Mathematics for the Naval and Military Academy by Dr Rutherford and others. There have also been works constructed for the benefit of students, which may be used with any treatise on the subject; such as the excellent collection of examples by Pea-

cock, Herschel, and Babbage, which was intended as an accompaniment to an English translation of an abridgment of Lacroix's treatise; and the integral tables of Hirsch, which have been translated from the original German into English. And since then Hind's Exercises on the Differential Calculus, and Gregory's Exercises in the Differential and Integral Calculus.

There is a branch of the calculus of great interest, which of late has engaged, and will probably long engage, the attention of mathematicians; we mean the subject of *Elliptic Transcendents*. This theory originated in the discovery of a very remarkable property of the ellipse and hyperbola by Fagnani, an Italian mathematician, who first showed that arcs of these curves can be assigned, of which the difference is expressible in finite algebraic terms. Legendre, who gave this name to functions represented by the integrals of this form, discovered several of their very remarkable properties, and deduced from them the means of calculating their approximate values. For all the interesting but lengthy and minute details of these important investigations, we must refer those who feel desirous of investigating them thoroughly, to the following list of treatises on the subject. The student, however, should be aware that the term fluxion is very seldom used by the best scientific scholars of the present time. The reader of such works should also be aware that not only is the notation of Newton different from that of Leibnitz, but that which the latter calls *difference* the former calls *fluxion*, because he supposes that the co-ordinates, and in general the quantities augmented indefinitely and gradually were produced by a flowing or fluxion of infinitely small parts.

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Bossut, Leipsic Acts, 1754; Mém. de Math. et de Phys. tom. iii.
Landen, Lond. Phil. Trans. 1775; and Mathematical Lucubrations 1780
Legendre, Mém. de l'Acad. des Sciences, 1786; Mémoire sur les Transcendantes Elliptiques, 1792. (There is an English translation of this memoir in Leyburn's Mathematical Repository, vols. ii. and iii. new series.) Exercises de Calcul Intégral, 3 vols.; Schumacher's Journal, Nos. 123, 127, 130.
——— Traité des Fonctions Elliptiques 1825
——— Miscell. Taur. tom. iv.; Théorie des Fonct. Analytiques, 2d edit.
Ivory, New Series for the Rectification of the Ellipse, Trans. R. S. Edin. vol. iv.; Fagnani's Theorem made more general, Leyburn's Math. Repository, vol. i. new series; On the Theory of the Elliptic Transcendents, Trans. R. S. Lond. 1831.
Wallace, Formula for the Rectification of an Ellipse, &c., Trans. R. S. Edin. vol. v.
Woodhouse, Integration of Certain Differentials, Trans. R. S. Lond. 1804.
Brinkley, Demonstration of Fagnani's Theorem, Trans. Irish Acad. vol. ix.
Abel, J. Crell's Journal, vol. ii.
Jacobi Fundamenta Novæ Theoriæ Functionum Ellipticarum 1829
Plana, Memoir read in the Turin Academy 1828

Many other papers on the above subject may be found in the mathematical journals mentioned at the end of the preceding list, besides numerous smaller works which do not deserve mention here, though possessing great merit.

PART I.

DIRECT METHOD OF FLUXIONS, OR DIFFERENTIAL CALCULUS.

1. In the application of algebra to the theory of curve lines, some of the quantities under consideration are conceived as having always the same magnitude as the parameter of a parabola, and the axes of an ellipse or hyperbola; others again are indefinite in respect of magnitude, and may have any number of particular values; such are the co-ordinates at any point in a curve. This difference in the nature of the quantities has equally place in various theories of the pure and mixed mathematics, and it naturally suggests the division of all quantities into two kinds; namely, such as are constant, and such as are variable.

A constant quantity is that which is supposed to have always the same value. A variable quantity, again, is that which may change its value by increasing or decreasing, so that in passing from one degree of magnitude to another it will have had in succession every possible intermediate magnitude.

Thus, in a circle, the radius is a constant quantity, and any arc of the circle, also its cosine, sine, tangent, secant, &c. are variable quantities. In the ellipse, the axes or semiaxes are considered as constant; and the co-ordinates to any point in the curve, and in general any lines or spaces or angles which in the same ellipse admit of different values, are variable. So again in the parabola, the parameter is constant, and the co-ordinates to any point in the curve, also any arc of the curve, and the space contained by that arc and the co-ordinates, are to be regarded as variable.

In what follows, we shall in general call constant quantities simply *constants*, and variable quantities *variables*.

It is usual to denote constants by the letters a, b, c, &c. towards the beginning of the alphabet, and variables by the letters x, y, z, &c. towards the end.

2. One quantity is said to be a *function* of another when they are so related that the latter being supposed to change its value, the former also changes its value. Thus, in geometry, the radius of a circle being constant, the cosine, the sine, the tangent, the secant, &c. are functions of the arc. On the other hand, the arc may be considered as a function of any one of these quantities. In mechanics, the force by which a body is urged forward, the space it has passed over, and its velocity at every instant, may all be regarded as functions the time.

In this algebraic expression,

$$y = \frac{a + x}{a - x},$$

in which a is a constant and x a variable, the quantity y is regarded as a function of x, which is called the *independent* variable. Here y is expressed by x; but by resolving the equation, x may be expressed by y thus:

$$x = \frac{a(y-1)}{y+1};$$

the quantity x is now a function of y. In either case, the constants a and 1 are not considered. In these examples,

$$u = a + bx + cx^2,$$
$$u = \sqrt{(a^2 + bx + x^2)},$$
$$u = \frac{a + \sqrt{bx}}{c + x^2},$$

u is a function of x.

A quantity may be a function of several independent variable quantities. Thus, in the expression

$$u = ax^2 + bxy + cy^2,$$

u is a function of the independent variables x and y.

The variety of forms of functions of a variable is endless. They may, however, be resolved into a few elementary functions such as these,

$$x^n, \quad a^x, \quad \log x, \quad \sin x, \quad \cos x.$$

The first of these, x^n, in which n is constant, and all that can be formed from it by a finite number of the elemen-

tary operations of algebra, are called *algebraic* functions; for example, this,

$$u = ax^3 + \frac{bx^2 - c^2x}{\sqrt{a^2 + x^2}},$$

which is formed by addition, subtraction, multiplication, division, and the extraction of the square root. These two, a^x, $\log x$, which cannot be expressed by a finite number of terms composed of powers of x, are called *transcendental* functions, and the remaining two, $\sin x$, $\cos x$, and such as may be formed from them, viz. $\tan x$, $\sec x$, &c. are called *trigonometrical*, also *angular* and *circular* functions.

In the last example, the value of the function u may be immediately found, if the value of x be known. Such functions are called *explicit*. There are functions, however, which require to be separated from the variable by the resolution of equations, or other means, before their value can be found; as in this example,

$$ux = \frac{u + x}{u - x},$$

in which u is supposed to be a function of x. In this case, before the value of u, corresponding to a given value of x, can be found, a quadratic equation must be resolved. Such a function is called an *implicit* function of x. On the other hand, x is an implicit function of u. By the resolution of an equation we find

$$u = \frac{1}{2}\left\{x + \frac{1}{x} + \frac{\sqrt{x^4 + 6x^2 + 1}}{x}\right\};$$

u is now an explicit function of x.

The early algebraists indicated the square root of a quantity by placing the letter r before it; thus rx meant the square root of x. The letter was afterwards changed into the sign $\sqrt{}$, and the square root of x was conveniently expressed thus, $\sqrt{x}$. In like manner, it is convenient to have a symbol which shall express generally a function of a variable, and accordingly it is now usual to express any function of a variable x by the symbol fx or $f(x)$; also by Fx, or φx. Here the letters f, or F, or φ, are considered merely as the abbreviation of the word *function*, and not as a co-efficient to the letter x. In this way we include all these expressions,

$$u = x^n, \quad u = a^x, \quad u = \log x, \quad u = \cos x, \quad u = \sin x,$$

in one general expression, viz. $u = fx$, or $u = f(x)$.

When a function depends on two variable quantities x, y, which are independent of each other, such as this expression,

$$u = ax^2 + bxy + cy^2,$$

we shall express it thus,

$$u = f(x, y).$$

Here we take no notice of the constant quantity a, b, c. A like notation may be applied when three independent variables enter a function.

3. The manner in which we propose to treat this subject requires that the reader should distinctly understand what is meant by a *limit* to the value of a variable function, or a variable ratio. In the elements of geometry it is shown that the area of a circle is less than that of any regular polygon described about it; and that the greater the number of sides of the polygon, the more nearly is its area equal to that of the circle; so that any space being given, however small, a polygon may be described about the circle, which shall differ from it by less than that space. Suppose now a series of polygons to be described about a circle, each having the number of its sides greater than that which preceded it, the double for example. These will approach continually to an equality with the circle as a *limit*, which the series, however far continued, can never absolutely reach in respect of magnitude, but from which some term, and all that follow it, may differ by less than any space assignable.

In like manner, the circle is the limit of the area of all regular polygons inscribed in it; and the circumference of the circle is the limit of the perimeters of regular polygons described in it or about it.

In our article ALGEBRA (sect. 266) it has been shown, that, putting a for an arc of a circle, the fraction $\frac{a}{\sin a}$ is always greater than an unit, but that $\frac{a}{\tan a}$ is always less; farther, that the arc being supposed to decrease continually, these fractions approach to each other, and may differ by less than any assignable quantity; therefore unity, which is always between them, is their common limit. Hence it appears, that of these three quantities, an arc, its sine, and its tangent, the limit of the ratio of any two is that of equality. In the same article it has been shown that the arc a is the limit of the fractions $n \tan. \frac{a}{n}$ and $n \sin \frac{a}{n}$, supposing the number n to be increased continually.

The geometrical series

$$1 + x + x^2 + x^3 \ldots. + x^{n-1}$$

is equivalent to the function $\frac{1 - x^n}{1 - x}$ (ALGEBRA, sect. 56); when x is less than 1, and n is infinitely great, then $x^n = 0$, and the function $= \frac{1}{1 - x}$; therefore, in this case, the sum of any finite number of terms of the series will always be less than $\frac{1}{1 - x}$, but will approach to it as the number of terms increases, and may differ from it by less than any assignable quantity; hence it follows that the function $\frac{1}{1 - x}$ is the limit of the sum of the series.

By the binomial theorem

$$\left(1 + \frac{x}{n}\right)^n = 1 + \frac{x}{1} + \frac{x^2}{1\,.\,2}\left(1 - \frac{1}{n}\right)$$
$$+ \frac{x^3}{1\,.\,2\,.\,3}\left(1 - \frac{1}{n}\right)\left(1 - \frac{2}{n}\right) +, \text{ \&c.}$$

This is true, whatever be the numerical value of n; but suppose n to be a large number, then the factors $1 - \frac{1}{n}$, $1 - \frac{2}{n}$, &c. will differ but little from unity; and they will differ the less as n is greater. Suppose now n to be indefinitely great, then these factors may be accounted each equal to an unit; and, therefore,

$$\left(1 + \frac{x}{n}\right)^n = 1 + \frac{x}{1} + \frac{x^2}{1\,.\,2} + \frac{x^3}{1\,.\,2\,.\,3} +, \text{ \&c.}$$

It has been shown in algebra (sect. 177) that the second member of this equation is the development of the function e^x, where e denotes the number 2·7182818, viz. the base of Napier's logarithms; therefore, if n be supposed to increase continually, the expression $\left(1 + \frac{x}{n}\right)^n$ will approach to e^x as its limit; and making $x = 1$, the limit of $\left(1 + \frac{1}{n}\right)^n = e = 2{\cdot}7182818$, a constant quantity.

4. Since the value of a function depends essentially on that of the variable, which is its basis, any change in the value of the latter will produce a corresponding change in the value of the former.

First, let the function be $u = x^2$, and let us suppose that the variable changes its value, being increased by a quantity h, and thereby becoming $x + h$; let u' denote the corresponding value of u, so that we have

$$u' = (x + h)^2 = x^2 + 2xh + h^2 = u + 2xh + h^2;$$

hence $u' - u = 2xh + h^2$.

It thus appears that, h denoting the increment of the variable x, the corresponding increment of the function, viz. $u' - u$, is $2xh + h^2$.

The algebraic expression for a ratio is a fraction whose numerator is the antecedent, and denominator the consequent. In the present case, the ratio of the increment of the function to that of its variable is

$$\frac{u' - u}{h} = 2x + h.$$

As another example, let the function be $u = x^3$; then, supposing, as before, that the variable x is increased by the quantity h, and, putting u' for the new value of the function, we have

$$u' = (x + h)^3 \begin{cases} = x^3 + 3x^2h + 3xh^2 + h^3 \\ = u + 3x^2h + 3xh^2 + h^3; \end{cases}$$

$$\frac{u' - u}{h} = 3x^2 + 3xh + h^2.$$

In this case we see that when x has increased to $x + h$, the function u has become

$$u + 3x^2h + 3xh^2 + h^3,$$

having received the increment $3x^2h + 3hx^2 + h^3$, a quantity composed of the integer powers of h. Farther, it appears that the expression for the ratio of the increments is

$$3x^2 + 3xh + h^2,$$

of which the first term $3x^2$ is entirely independent of the value of h, the increment of x.

When the function is $u = x^4$, we have, putting, as in the former examples, h for the increment of the variable, and u' for the new value of the function,

$$u' = u + 4x^3h + 6x^2h^2 + 4xh^3 + h^4,$$

$$\frac{u' - u}{h} = 4x^3 + 6x^2h + 4xh^2 + h^3.$$

From these examples it appears, that when x changes its value and becomes $x + h$, then the new value of the function

$u = x^2$ becomes $u' = u + 2xh + h^2$,
$u = x^3$ becomes $u' = u + 3x^2h + 3xh^2 + h^3$,
$u = x^4$ becomes $u' = u + 4x^3h + 6x^2h^2 + 4xh^3 + h^4$;

and in general that

$u = x^n$, any integer power of x, becomes
$u' = u + ph + qh^2 + rh^3 + sh^4 +$, &c.

the new value of the function being composed of a series of terms, the first of which is its original value, and the following terms, integer powers of the increment h, multiplied by p, q, r, &c. certain other functions of x, the forms of which depend on the original function, whence they have been derived.

Farther, it appears that

when $u = x^2$, then $\dfrac{u' - u}{h} = 2x + h$;

when $u = x^3$, $\dfrac{u' - u}{h} = 3x^2 + 3xh + h^2$;

when $u = x^4$, $\dfrac{u' - u}{h} = 4x^3 + 6x^2h + 4xh^2 + h^3$;

and, in general, that when $x = u^n$, n being any whole number, then

$$\frac{u' - u}{h} = p + qh + rh^2 + sh^3 +, \text{\&c.}$$

Thus it appears that the expression for $\dfrac{u' - u}{h}$, the ratio of the increment of the function x^n to that of its variable x, may be resolved into two parts, one, p, which is independent of the increment, and another, $qh + rh^2 + sh^3 +$, &c.; or

$$h(q + rh + sh^2 +, \text{\&c.}),$$

which, having h the increment as a factor, must decrease with it, and, by giving a sufficiently small value to h, may become less than any assignable quantity, so that the first term p is the limit of the ratio.

Let us consider the complex function

$$u = a + bx + cx^2.$$

When x becomes $x + h$, u becomes

$$u' = a + b(x + h) + c(x + h)^2$$
$$= a + bx + cx^2 + (b + 2cx)h + ch^2,$$

hence $u' - u = (b + 2cx)h + ch^2$,

$$\frac{u' - u}{h} = b + 2cx + ch.$$

In this case the limit of the ratio is $b + 2cx$. By a like examination of particular functions it will be found that they have all a common property, that is,

If u *be any function of a variable* x, *and if in that function* x *be supposed to change its value and become* x + h; *the corresponding new value of the function will be*

$$u' = u + ph + qh^2 + rh^3 +, \text{\&c.}$$

and the ratio of the increments of the function and its variable,

$$\frac{u' - u}{u} = p + qh + rh^2 +, \text{\&c.};$$

an expression which, when h *is supposed to decrease continually, has for its limit the first term* p; *and this limit will be different for different functions, there being such a connection between the function and its limit, that the one may be found from the other.*

This property of the increments of a function and its variable suggests an important and extensive analytical theory, which will consist of two parts.

I. Any function of a variable quantity being proposed, to determine the limit of the ratio of the corresponding increments of the function and its variable.

II. On the other hand, having given the ratio of the increments, to find the function from which it has been derived.

These two inquiries constitute at bottom the *Direct and Inverse Method of Fluxions* of Newton, the *Differential and Integral Calculus* of Leibnitz, and the *Theory of Functions* of Lagrange. Our present subject is the direct method of fluxions, or its equivalent, the differential calculus.

5. We have seen (4), that by the transition of a function, for example, $u = x^2$, from one state of magnitude to another, by a change in the magnitude of its variable x, it acquires the new value $u' = u + 2xh + h^2$. The *whole difference* $u' - u$ between its new and first values is $2xh + h^2$. It is the first term of this difference, viz. $2xh$, that constitutes what is called the *differential* of the function from which it has been derived; and the determination of this first term for any function is the object of this first part of our calculus.

In like manner, in the function $u = x^3$, which, when x becomes $x + h$, changes to $u' = u + 3x^2h + 3xh^2 + h^3$, the whole difference between the two states of magnitude of the function is $3x^2h + 3xh^2 + h^3$, and its differential is $3x^2h$. And the whole difference between the first and succeeding value of the function $u = x^4$ is $4x^3h + 6x^2h^2 + 4xh^3 + h^4$, and its differential, is $4x^2h$. And, in general, whatever be the nature of the function u, if $x + h$ be substituted in it instead of x, and the expression thus formed be expanded into a series,

$$u + ph + qh^2 + rh^3 + sh^4, \text{\&c.}$$

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the complete difference between the two states of the function is

$$ph + qh^2 + rh^3 + sh^4 +, \&c.$$

and its differential is the first term ph.

In conformity with this definition, the differential of the variable x itself will be its increment h, which, because of its use in generating the differential of the function, has been designated by a peculiar symbol, viz. dx: here the letter d is to be understood as a characteristic, not as a co-efficient. The letter d is also prefixed to the symbol for a function to denote its differential. Thus, supposing $u = x^2$, we have $du = 2xdx$, an expression which means that the differential of the function u is equal to the differential of the variable multiplied by $2x$ as a co-efficient; so also, if $u = x^3$, the equation $du = 3x^2dx$ means that the differential of u is equal to the differential of x multiplied by $3x^2$.

6. Since, when $u = x^2$, then $du = 2xdx$, this last expression may otherwise stand thus, $\frac{du}{dx} = 2x$; under this form $2x$ is the co-efficient in the expression for the differential of u, and it is on that account called the *differential co-efficient* of the function u or x^2. In like manner, when $u = x^3$, then $du = 3x^2dx$ and $\frac{du}{dx} = 3x^2$; in this case $3x^2$ is the differential co-efficient of the function $u = x^3$. The general symbol for the differential co-efficient of any function u is $\frac{du}{dx}$, and the new value of u being $u + ph + qh^2 +$, &c. we have $\frac{du}{dx} = p$, where p is some function of x, which depends on the form of the function u, and is deducible from it when its form is known.

To denote the differential of an expression formed in any way, we prefix the symbol d to the expression. Thus $d\{(a+x)(b^2-x^2)\}$ denotes the differential of a function produced by multiplying the factors $a+x$ and b^2-x^2, and $\frac{d\{(a+x)(b^2-x^2)\}}{dx}$ serves to denote its differential co-efficient.

The definition which has been given of a differential suggests immediately this rule for finding the differential of a function of a single variable.

Substitute x + h *in the function instead of* x; *expand the expression thus formed into a series of terms composed of integer powers of* h, *and take the term which contains the first power of* h *for the differential, exchanging the letter* h *for the symbol* dx.

Thus, let the function be $u = ax + bx^2$, in which a and b are constants, then, putting $x + h$ for x, and u' for the new value of u, we have

$$u' \begin{cases} = a(x+h) + b(x+h)^2 \\ = ax + bx^2 + (a+2bx)h + bh^2 \\ = u + (a+2bx)h + bh^2. \end{cases}$$

Here du, the differential of the function, is $(a+2bx)h$, or $(a+2bx)dx$, and $\frac{du}{dx} = a + 2bx$ the differential co-efficient.

7. The rule given in last article, for determining the differential of a function, supposes that we have methods by which any function may be expanded into a series of terms, into each of which some integer power of the increment h enters only as a factor. It is sufficient for our purpose, however, if we can find that term of the series which contains the simple power of h; and this can in general be found easier than the general development, which indeed may be the very thing to be investigated by the calculus. Now we have seen (4) that the co-efficient of this term is the expression for the limit of the ratio of the corresponding increments of a function and its variable, and the same quantity is the differential co-efficient of the function (6), therefore the determination of the differential of a function is the same thing as the determination of the limit of the ratio of the increments.

Let the function be $u = \frac{a^2}{x}$; then $u' = \frac{a^2}{x+h}$, and

$$u' - u = \frac{a^2}{x+h} - \frac{a^2}{x} = \frac{-a^2h}{x(x+h)};$$

and the limit of the ratio of the increments is

$$\frac{u'-u}{h} = \frac{-a^2}{x(x+h)}.$$

Now, without expanding the expression for the limit, it is obvious that as h decreases, that expression approaches to $-\frac{a^2}{x^2}$, which is therefore $\frac{du}{dx}$, the differential co-efficient of the function; hence $du = -\frac{a^2dx}{x^2}$. In like manner, u being the general expression for any function, and $u' = u + ph + qh^2 +$, &c. its expanded value when $x + h$ is put instead of x, we have

$$\frac{u'-u}{h} = p + qh +, \&c.$$

$$\text{and limit of } \frac{u'-u}{h} = p = \frac{du}{dx}, \text{ and } du = pdx.$$

According to this view of the subject, *the differential calculus is the finding of the ratios of the simultaneous increments of a function and of the variable on which it depends.*

The process of calculation by which the differential of any function u is found, may be regarded as a particular operation performed on quantity, analogous to the elementary operations of algebra; and it may, like these, be distinguished by a particular name accordingly. The result of the process being the *differential*, the process itself is called *differentiation*, and to perform the process on a function is to *differentiate* the function.

8. It is material to observe, that the limit of the ratio of the increments of a function and its variable are the very same, whichever of the two be considered as a function of the other. Thus, u being a function of x, when x becomes $x + h$, u becomes $u + ph + qh^2 + rh^3 +$, &c. p, q, r, &c. being functions of x, deducible from the function u. Let us put

$$k = ph + qh^2 + rh^3 +, \&c.$$

so that the contemporaneous increments of x and u are h and k. Now, from the value of k, by the reversion of series (ALGEBRA, art. 163), we find

$$h = \frac{1}{p}k - \frac{q}{p^3}k^2 +, \&c.$$

So that, regarding x as a function of u, when u becomes $u + k$, x becomes

$$\frac{1}{p}k - \frac{q}{p^3}k^2 +, \&c.$$

and the general expression for the ratio of the increments is

$$\frac{h}{k} = \frac{1}{p} - \frac{q}{p^3}k +, \&c.$$

which has for its limit $\frac{1}{p}$, and the limit of the ratio $\frac{k}{h}$ is, as before, $= p$.

9. It is easy to see that two equal functions must have equal differentials; for whatever be the value of the va-

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riable on which they depend, it must necessarily happen that the respective changes they receive in consequence of the change which is attributed to the variable must also be equal. Thus, if u and v be two functions, such, that $u = v$, whatever may be the value of x; and if, when x becomes $x + h$, then u becomes u', and v becomes v', we shall have $u' = v'$, and $u' - u = v' - v$, and

$$\frac{u' - u}{h} = \frac{v' - v}{h}.$$

If then p and q denote the limits of these ratios, $p = q$ and $pdx = qdx$, that is, $du = dv$.

From this it follows, that under whatever form a function appears, its differential is the very same quantity. For example, the differential of $x^3 + a^3$ will be identical with the differential of $(x + a)(x^2 - ax + a^2)$, its equal.

The converse of this proposition is not generally true, and we should be wrong in affirming that two equal differentials belong to equal functions. For, let $u = a + bx$ be a function of x, then, substituting $x + h$ for x, and putting u' for the new value of u, we have $u' = a + bx + bh = u + bh$, and $\frac{u' - u}{h} = b$.

We see here that the constant a does not enter into the limit of the ratio of the increments, which would therefore be the very same for the function $u = bx$; hence it follows that the differential bdx belongs alike to $a + bx$, and to bx. Thus it appears, that in differentiating any function whatever, all the constant quantities combined with it, either by addition or subtraction, disappear. With respect to those which are connected by multiplication and division, they enter the result as co-efficients.

10. The differential of any function of a variable x may be found by the general methods indicated in article 6; but it is convenient to have rules adapted to particular cases.

Let r and s be two functions of a variable x. It is proposed to investigate a rule for finding the differential of $u = rs$, their product.

Suppose that by the substitution of $x + h$ for x in the functions r and s, and their expansion, they become

$r' = r + ph + qh^2 +$, &c. $s' = s + p'h + q'h^2 +$, &c.

In these expressions, p, q, &c. represent functions of x, derived from r; and p', q', &c. other functions of x derived from s. Corresponding to these let u' denote $r's'$, the new value of the product $rs = u$. By actual multiplication we find

$u' = r's' = rs + (rp' + sp)h + (rq + pp' + sq)h^2 +$, &c.

Hence, putting u for rs, also transposing and dividing by h, there is got

$$\frac{u' - u}{h} = rp' + sp + (rq' + pp' + sq)h +, \&c.$$

The terms rp' and sp in the second member of this equation are functions of x, which are independent of the function h; the following terms are all multiplied by h, therefore they decrease and vanish with it. So that

$$\text{limit of ratio } \frac{u' - u}{h} = rp' + sp.$$

$$\text{Now } p = \text{limit of } \frac{r' - r}{h}, \text{ and } q = \text{limit of } \frac{s' - s}{h}.$$

Instead of the limits of the ratios, let us put the differential co-efficients of the functions u, r, s (art. 6), and we find

$$\frac{du}{dx} = r\frac{ds}{dx} + s\frac{dr}{dx},$$

$$\text{and } du = rds + sdr.$$

Hence we have this rule, *To find the differential of the product of two functions, multiply the differential of each by the differential of the other function, and add the products.*

11. Since, when $u = rs$, we have $du = sdr + rds$, it follows that

$$\frac{du}{u} = \frac{dr}{r} + \frac{ds}{s}.$$

If we suppose $u = rtv$, the product of three factors, by putting $s = tv$, we have $u = rs$, and

$$\frac{du}{u} = \frac{dr}{r} + \frac{ds}{s};$$

but since $s = tv$, we have for the same reason

$$\frac{ds}{s} = \frac{dt}{t} + \frac{dv}{v};$$

$$\text{therefore } \frac{du}{u} = \frac{dr}{r} + \frac{dt}{t} + \frac{dv}{v}.$$

By writing the product rs instead of u, there is got, after proper reduction,

$$du = tvdr + rvdt + rtdv.$$

In general, *If a function be the product of any number of functions of a variable, its differential is the sum of the products obtained by multiplying the differential of each by the product of all the other functions.*

The same rule may also be briefly expressed in symbols, thus: whatever be the number of functions r, s, t, v,

$$d\,(rstv) = rstv\left\{\frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t} + \frac{dv}{v}\right\}.$$

12. To find the differential of a fraction whose numerator and denominator are functions of a variable x; let $u = \frac{r}{s}$, then $r = us$, and

$$dr = uds + sdu,$$

and, putting for u its value $\frac{r}{s}$,

$$dr = \frac{rds}{s} + sdu;$$

$$\text{therefore, } du = \frac{sdr - rds}{s^2}.$$

Hence we have this rule: *To find the differential of a fraction; from the differential of the numerator multiplied by the denominator subtract the differential of the denominator multiplied by the numerator, and divide by the square of the denominator.*

The rule for the differential of $u = \frac{r}{s}$ may be also symmetrically expressed thus:

$$\frac{du}{u} = \frac{dr}{r} - \frac{ds}{s};$$

and in general, if $u = \frac{rst}{vy}$, then

$$\frac{du}{u} = \frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t} - \frac{dv}{v} - \frac{dy}{y}.$$

For, by what has been shown, it appears that when $u = \frac{rst}{vy}$, then

$$\frac{du}{u} = \frac{d(rst)}{rst} - \frac{d(vy)}{vy},$$

$$\text{Now } \frac{d(rst)}{rst} = \frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t},$$

$$\text{and } \frac{d(vy)}{vy} = \frac{dv}{v} + \frac{dy}{y};$$

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therefore, $\frac{du}{u} = \frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t} - \frac{dv}{v} - \frac{dy}{y}$.

It also follows, from what has been shown, that if the numerator of a fraction consist of any number of factors r, s, t, and the denominator of any number v, y, then

$$d\left\{\frac{rst}{vy}\right\} = \frac{rst}{vy}\left\{\frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t} - \frac{dv}{v} - \frac{dy}{y}\right\}.$$

13. We shall next investigate a rule for the differential of any power of a function y, which may be either itself an independent variable, or else some function of another variable.

First, let $u = y^n$, n being any whole number. The function may be put under this form,

$$u = y \cdot y \cdot y \cdot y \ldots \text{ to } n \text{ terms,}$$

and then (11) we have

$$\frac{du}{u} = \frac{dy}{y} + \frac{dy}{y} + \frac{dy}{y} + \frac{dy}{y} \ldots \text{ to } n \text{ terms;}$$

that is, $\frac{du}{u} = \frac{ndy}{y}$,

$$\text{and } du = \frac{ndy}{y} u = ny^{n-1}\, dy.$$

Next, let us suppose that the function has a fractional exponent, and that $u = y^{\frac{m}{n}}$, then $u^n = y^m$,

and $nu^{n-1}\, du = my^{m-1}\, dy$, by art. 9,

$$\text{and } du = \frac{m}{n} \frac{y^{m-1}}{u^{n-1}}\, dy;$$

$$\text{but } u = y^{\frac{m}{n}} \text{ and } u^{n-1} = y^{m - \frac{m}{n}};$$

$$\text{therefore } \frac{y^{m-1}}{u^{n-1}} = y^{\frac{m}{n} - 1},$$

$$\text{and } du = \frac{m}{n} y^{\frac{m}{n} - 1}\, dy$$

Lastly, let us suppose n to be a negative whole number or fraction, so that $u = \frac{1}{y^n}$. In this case we may apply the rule for a fraction (12); and observing that the numerator here is a constant, of which the differential must be accounted $= 0$, we have

$$du = -\frac{ny^{n-1}dy}{y^{2n}} = -ny^{-n-1}dy;$$

thus it appears, that whether n be whole or fractional, positive or negative,

$$d(y^n) = ny^{n-1}dy.$$

Hence this rule: *To differentiate any power of a function, multiply it by the exponent, diminish the exponent by an unit, and multiply by the differential of the variable.*

If the function have a co-efficient, the differential must be multiplied by that co-efficient. Thus

$$d(ax^n) = nax^{n-1}\, dx.$$

The determination of the differential of a power of a variable might have been shortened by assuming the truth of the binomial theorem, as found in our article ALGEBRA, art. 160, 161. That theorem however may be derived from the differential calculus, and we shall give its investigation as one of its applications.

It frequently happens that the differential of $\sqrt{y} = y^{\frac{1}{2}}$, the square root of a function, is to be found; therefore a rule for that case will be convenient. By the general rule for a power,

$$d(y^{\frac{1}{2}}) = \tfrac{1}{2}y^{\frac{1}{2}-1}dy = \tfrac{1}{2}y^{-\frac{1}{2}}dy,$$

$$\text{that is, } d(\sqrt{y}) = \frac{dy}{2\sqrt{y}}.$$

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Hence it appears that *the differential of the square root of a function is the differential of the function divided by twice its square root.*

14. Let y be a function of a variable x, and let u be a function of y; it is proposed to investigate a rule for finding the differential of u relatively to x.

Suppose x to change its value and become $x + h$, then y becomes $y' = y + ph + qh^2 + rh^3 +$, &c.; or, putting $ph + qh^2 + rh^3 +$, &c. $= k$, y becomes $y + k$. But u being a function of y, when y becomes $y + k$, then u becomes $u' = u + p'k + q'k^2 + r'k^3 +$, &c.; here p', q', r', &c. denote certain functions of y, which are independent of k and also of h. Hence, by substituting for k in this last series, its value $ph + qh^2 +$, &c., it appears that when x becomes $x + h$, u becomes

$$u' = u + p'ph + (p'q + q'p^2)\, h^2 +, \&c.$$

$$\text{and hence } \frac{u' - u}{h} = p'p + (p'q + q'p^2)h +, \&c.$$

Suppose now h to decrease continually, we have

$$\text{limit of } \frac{u' - u}{h} = p'p.$$

Now, y being a function of x, $p = \frac{dy}{dx}$, and u being considered as a function of y, $p' = \frac{du}{dy}$; but if we consider u as a function of x, then

$$\frac{du}{dx} = \text{limit } \frac{u' - u}{h} = p'p.$$

Hence it follows that

$$\frac{du}{dx} = \frac{du}{dy} \times \frac{dy}{dx},$$

$$\text{and } du = \left(\frac{du}{dy} \times \frac{dy}{dx}\right)dx.$$

Hence this rule: To find, relatively to x, the differential of u, a function of y, the quantity y being a function of x, *Find the differential co-efficient of* u *considered as a function of* y *only, and the differential co-efficient of* y *considered as a function of* x; *multiply the product of these co-efficients by the differential of* x, *and the result is the differential of* u.

It has been found that

$$\frac{du}{dy} \times \frac{dy}{dx} = \frac{du}{dx};$$

Now if we suppose that $u = x$, then this expression becomes

$$\frac{dx}{dy} \times \frac{dy}{dx} = \frac{dx}{dx} = 1;$$

and hence it appears that

$$\frac{dx}{dy} = \frac{1}{\frac{dy}{dx}}.$$

This shows that the differential co-efficient of x considered as a function of y, is the reciprocal of the differential co-efficient of y considered as a function of x, a conclusion which may also be deduced from art. 8.

15. Let v, y, z be functions of a variable x, and let it be proposed to find the differential of

$$u = a + bv + cy - ez,$$

where a, b, c, e, denote constants.

Let us suppose that when x becomes $x + h$, then

$$v \text{ becomes } v + ph + qh^2 +, \&c.$$
$$y \text{ becomes } y + p'h + qh^2 +, \&c.$$
$$z \text{ becomes } z + p''h + q''h^2 +, \&c.$$

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Let u' be the corresponding value of u, so that

$$u'=\begin{cases}a+bv+cy-ez\\+(bp+cp'-ep'')h\\+(bq+cq'-eq'')h^2\\+,\ \&c.\end{cases}$$

Hence, putting for the first term of the second member of the equation its value u, and transposing and dividing by h, we get

$$\frac{u'-u}{h}=bp+cp'-ep''+(bq+cq'-eq'')h,\ \&c.$$

And passing to the limits, observing that the limit of $\frac{u'-u}{h}$ is the differential co-efficient of u, also that p, p', and p'' are the differential co-efficients of v, y, and z respectively, we get

$$\frac{du}{dx}=\frac{bdv}{dx}+\frac{cdy}{dx}-\frac{edz}{dx},$$

and $du=bdv+cdy-edz$.

From this it appears that *the differential of a function made up of others simply by addition and subtraction is composed in like manner of the differentials of the several terms, each with the sign of the function from which it was derived; the differential of a constant being reckoned* $=0$.

16. These rules are sufficient for the differentiation of any explicit algebraic function, and we shall now give examples.

1. Let $u=ax^5$; this is a particular case of the general function $u=ax^n$; therefore, by the rule (13) $du=5ax^4dx$.

2. Let $u=\frac{a}{x^5}=ax^{-5}$; then $du=-5\,ax^{-6}\,dx=\frac{-5adx}{x^6}$.

3. Let $u=\sqrt{x^3}=x^{\frac{3}{2}}$; in this case $du=\frac{3}{2}x^{\frac{1}{2}}dx=\frac{3}{2}\,dx\sqrt{x}$.

4. Let $u=ax^3+bx^2+cx+e$;
then $du=3ax^2dx+2bxdx+cdx$,
or $du=(3ax^2+2bx+c)\,dx$.

Here the constant e, which is a term of the function, has disappeared by the differentiation.

5. Let $u=(a+bx^n)^p$; we may put $y=a+bx^n$, and then $u=y^p$; and $du=py^{p-1}dy$.

Now $y^{p-1}=(a+bx^n)^{p-1}$, and $dy=bnx^{n-1}dx$;

therefore $du=bnp\,(a+bx^n)^{p-1}x^{n-1}dx$.

We might have dispensed with using the symbol y, and regarded $a+bx^n$ as a single function, and u as a power of that function, and found the differential by the rule of art. 13.

As an example of the rule of art. 10, for the product of two functions,

6. Let $u=x^3\,(a+x)^2$;
put $p=x^3$, and $q=(a+x)^2$; then $u=pq$,
and $du=qdp+pdq$.

Now $dp=3x^2dx$, and $dq=2\,(a+x)\,dx$;
therefore $du=3x^2\,(a+x)^2\,dx+2x^3\,(a+x)\,dx$
$=x^2\,(a+x)\,(3a+5x)\,dx$.

In practice, the introduction of the symbols p and q may be omitted.

7. Let $u=x\,(1+x)\,(1+x^2)$. In this case, u is the product of three functions; therefore, by the rule of art. 11,
$du=(1+x)\,(1+x^2)\,dx+x\,(1+x^2)\,dx+2x^2\,(1+x)\,dx$.
This, when abbreviated by multiplication, becomes
$du=(1+2\,x+3x^2+4x^3)\,dx$.

We might have proceeded otherwise by the rule

$$d\,(rst)=rst\left\{\frac{dr}{r}+\frac{ds}{s}+\frac{dt}{t}\right\};$$

accordingly, we would have had

$$du=x(1+x)\,(1+x^2)\left\{\frac{dx}{x}+\frac{dx}{1+x}+\frac{2xdx}{1+x^2}\right\},$$

an expression reducible to the former.

8. As an example of a fractional function, let $u=\frac{x}{1+x^2}$; we have, following the rule of art. 12,

$$du=\frac{(1+x^2)\,dx-2\,x^2dx}{(1+x^2)^2}=\frac{(1-x^2)dx}{(1+x^2)^2}.$$

9. Again, let $u=\frac{x^3+x}{x^4-x^2+1}=\frac{x(x^2+1)}{x^4-x^2+1}$; this may exemplify the rule

$$d\left(\frac{rs}{t}\right)=\frac{rs}{t}\left\{\frac{dr}{r}+\frac{ds}{s}-\frac{dt}{t}\right\}.$$

Accordingly, making $x=r$, $x^2+1=s$, $x^4-x^2+1=t$, we have

$$du=\frac{x^3+x}{x^4-x^2+1}\left\{\frac{dx}{x}+\frac{2xdx}{1+x^2}-\frac{(4x^3-2x)\,dx}{x^4-x^2+1}\right\}.$$

This by reduction becomes

$$du=\frac{-\{x^6+4x^4-4x^2-1\}dx}{(x^4-x^2+1)^2}.$$

10. As an example of the rule in art. 14, let $u=3y^2$, and $y=x^3+ax$; then

$$\frac{du}{dy}=6y,\ \frac{dy}{dx}=3x^2+a;$$

$$\frac{du}{dy}\cdot\frac{dy}{dx}=6y\,(3x^2+a)=18\,x^2y+6ay,$$

$$\text{and } du=\frac{du}{dy}\cdot\frac{dy}{dx}\cdot dx=18x^2ydx+6aydx.$$

We may in such an example proceed otherwise, thus;
because $u=3y^2$, $du=6ydy$;
and since $y=x^3+ax$, $dy=3x^2dx+adx$,
substitute this value of dy in the expression for du, and it becomes

$$du=18x^2ydx+6aydx,$$

the same as before.

17. The subjects which are to follow require the application of the binomial theorem, we shall therefore give its investigation, as the first application of the calculus.

Supposing n to be any number whatever, whole or fractional, positive or negative, it is easy to infer, from the consideration of particular cases, that

$(1+x)^n=1+\mathrm{A}x+\mathrm{B}x^2+\mathrm{C}x^3+\mathrm{D}x^4+$, &c.,
the co-efficients A, B, C, &c., in the series being numbers altogether independent of x, and deducible from the index n alone. The expression $(1+x)^n$ and its development being equal for all values of x, they form an identical equation, and must have equal differentials, hence (art. 9) we have, taking the differential of each term,
$n(1+x)^{n-1}dx=\mathrm{A}dx+2\mathrm{B}xdx+3\mathrm{C}x^2dx+4\mathrm{D}x^3dx+$, &c.
Leaving now dx out of each term, and multiplying both sides by $1+x$, the result is
$n(1+x)^n=\mathrm{A}+(\mathrm{A}+2\mathrm{B})x+(2\mathrm{B}+3\mathrm{C})x^2+(3\mathrm{C}+4\mathrm{D})x^3$ $+$, &c.

But from the assumed series we have

$$n(1+x)^n=n+n\mathrm{A}x+n\mathrm{B}x^2+n\mathrm{C}x^3+,\ \&c.$$

Now the terms of these two expansions of $n(1+x)^n$ must be identical; therefore

$$\left.\begin{aligned}\mathrm{A}&=n,\\ \mathrm{A}+2\mathrm{B}&=n\mathrm{A},\\ 2\mathrm{B}+3\mathrm{C}&=n\mathrm{B},\\ 3\mathrm{C}+4\mathrm{D}&=n\mathrm{D},\\ \&\text{c}.\end{aligned}\right\}\text{and hence}\left\{\begin{aligned}\mathrm{A}&=n;\\ \mathrm{B}&=\frac{(n-1)}{2}\mathrm{A};\\ \mathrm{C}&=\frac{n-2}{3}\mathrm{B};\\ \mathrm{D}&=\frac{n-3}{4}\mathrm{C};\\ \&\text{c}.\end{aligned}\right.$$

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By substituting for A its value in B, and for B the resulting value in C, and so on, there is found

$$(1+x)^n=1+\frac{n}{1}x+\frac{n(n-1)}{1\ .\ 2}x^2+\frac{n(n-1)(n-2)}{1\ .\ 2\ .\ 3}x^3+\&c.$$

and again, by putting $\frac{v}{a}$ instead of x, and multiplying both sides of the equation by a^n, we get

$$(a+x)^n=a^n+\frac{n}{1}a^{n-1}x+\frac{n(n-1)}{1\ .\ 2}a^{n-2}x^2$$
$$+\frac{n(n-1)(n-2)}{1\ .\ 2\ .\ 3}a^{n-3}x^3+,\ \&c.$$

18. In the investigation of the binomial theorem we have employed a principle of analysis of continual use in the calculus, namely, that in such an equation as this (called an *Identical Equation*),

$a+bx+cx^2+ex^3+\&c.,=A+Bx+Cx^2+Ex^3+\&c.$ (1.)

in which a, b, c, &c., A, B, C, &c. are constants, and x is variable; in order that the equation may hold universally true, it is necessary that $a=A$, $b=B$, $c=C$, $e=E$, &c. For since x is indeterminate, we may suppose it to decrease until it vanish; then all the terms into which it enters also vanish, and we have $a=A$; therefore, leaving these equal terms out of both sides of (1), and dividing all the remaining terms by x, we get

$b+cx+ex^2+,\&c.,=B+cx+Ex^2+,\&c.$ (2.)

By proceeding with this equation as with the former, we obtain $b=B$, $c=C$, $e=E$, &c., and so on.

19. We come now to the investigation of the differentials of transcendental functions of a variable, and begin with the exponential function $u=a^x$, the exponent x being variable, and the quantity a constant. Assuming that when x becomes $x+h$, u becomes u', we have

$$u=a^x,\quad u'=a^{x+h}=a^x\ a^h;$$

therefore, $u'-u=a^x\ a^h-a^x=a^x(a^h-1)$;

$$\text{and } \frac{u'-u}{h}=a^x\frac{a^h-1}{h}.$$

The determination of the limit of the ratio of the increments requires that we determine the limit to which the value of the fraction $\frac{a^h-1}{h}$ tends when h is supposed to decrease continually. Let us put $a=1+c$; by the binomial theorem (art. 17),

$$a^h=(1+c)^h=1+hc+\frac{h(h-1)}{1\ .\ 2}c^2+\frac{h(h-1)(h-2)}{1\ .\ 2\ .\ 3}c^3+\&c.$$

therefore, $\frac{ah-1}{h}=c+\frac{h-1}{2}c^2+\frac{(h-1)(h-2)}{2\ .\ 3}c^3+\&c.$

Now h being supposed to decrease continually, the second side of this formula manifestly approaches to

$$c-\tfrac{1}{2}c^2+\frac{-1\ .-2}{2\ .\ 3}c^3+\frac{-1\ .-2\ .-3}{2\ .\ 3\ .\ 4}c^4+\&c.$$

that is, to $c-\frac{1}{2}c^2+\frac{1}{3}c^3-\frac{1}{4}c^4+,\&c.$

$=(a-1)-\frac{1}{2}(a-1)^2+\frac{1}{3}(a-1)^3-\frac{1}{4}(a-1)^4+,\&c.$

Now it has been shown in ALGEBRA (art. 173), and will be proved in the sequel, that this series expresses Napier's logarithm of the number a. Therefore,

$$\text{limit of } \frac{a^h-1}{h}=\text{Nap. log } a,$$

and hence, $\frac{du}{dx}=\text{limit}\frac{u'-u}{h}=a^x(\text{Nap. log } a)$,

$$\text{and } du=(\text{Nap. log } a)\ a^x dx.$$

We have now this rule for differentiating a function which is a variable power of a constant quantity.

Multiply the function by the differential of the variable index, and by Napier's log. of the constant quantity.

Note.—The logarithm of a number a, in any system whatever, will in what follows be expressed by the abbreviation log a; but when the system is that of Napier, we shall denote it thus, l. a.

20. To find the differential of the transcendental $u=\log x$, the base of the system being a. By the definition of a logarithm (ALGEBRA, art. 165),

$$x=a^u,$$

and, supposing that x becomes $x+h$, and that u becomes u',

$$x+h=a^{u'};$$

therefore, $h=a^{u'}-a^u=a^u(a^{u'-u}-1)=x(a^{u'-u}-1)$;

and hence, making $k=u'-u$,

$$\frac{h}{u'-u}=\frac{x(a^k-1)}{k};$$

$$\text{and } \frac{u'-u}{h}=\frac{1}{x}\cdot\frac{k}{a^k-1}.$$

Passing now to the limits of the two sides of the equation, and observing (as was proved in last article) that k being supposed to decrease continually,

$$\text{limit of } \frac{k}{a^k-1}=\frac{1}{\text{l.}\,a},$$

$$\text{we have } \frac{du}{dx}=\frac{1}{\text{l.}\,a}\cdot\frac{1}{x}.$$

Let M denote the constant factor, viz. the reciprocal of Napier's logarithm of the base of the system of logarithms, which is the modulus of the system (ALGEBRA, art. 172), and we have

$$du=\frac{Mdx}{x};$$

That is, *The differential of the logarithm of a number is found by multiplying the differential of the number by the modulus of the system and dividing by the number.*

Note.—In Napier's system M = 1.

21. The differentials of the trigonometrical functions $\sin x$ and $\cos x$ are next to be investigated.

Let $u=\sin x$, and $u'=\sin(x+h)$; then (ALGEBRA, 240),

$u'-u=\sin(x+h)-\sin x=2\cos(x+\frac{1}{2}h)\sin\frac{1}{2}h$,

$$\text{and } \frac{u'-u}{h}=\cos(x+\tfrac{1}{2}h)\frac{\sin.\frac{1}{2}h}{\frac{1}{2}h}.$$

Observing now that h being understood to decrease continually until it vanish, the limit of $\cos(x+\frac{1}{2}h)$ is $\cos x$, and the limit of $\frac{\sin\frac{1}{2}h}{\frac{1}{2}h}=1$ (ALGEBRA, 266), we have

$$\frac{du}{dx}=\text{limit}\frac{u'-u}{h}=\cos x;$$

$$\text{and } du=dx\cos x.$$

Next let $u=\cos x$, and $u'=\cos(x+h)$ we have now

$u'-u=\cos(x+h)-\cos x=-2\sin(x+\frac{1}{2}h)\sin\frac{1}{2}h$;

$$\frac{u'-u}{h}=-\sin(x+\tfrac{1}{2}h)\frac{\sin\frac{1}{2}h}{\frac{1}{2}h}.$$

Passing now to the limits by supposing h to decrease continually,

$$\frac{du}{dx}=\text{limit}\frac{u'-u}{h}=-\sin x;$$

$$\text{and } du=-dx\sin x.$$

Hence it appears that *The differential of the sine of an arc is the product of the differential of the arc and its cosine:*

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and that the differential of the cosine is the product of the differential of the arc and its sine with the sign — prefixed.

Note.—The negative sign indicates, that while the arc increases the cosine decreases when it is positive.

The differential of the cosine might have been found otherwise, by regarding it as a function of the sine. Thus, putting v for the sine, and y for the cosine; because $y^2 = 1 - v^2$, by differentiating, $ydy = -vdv$; now x being the arc, $dv = ydx$; therefore $ydy = -vydx$, and $dy = -vdx$.

22. The functions $u = \tan x$, $u = \cot x$, &c. may be considered as formed from the elementary functions sin x and cos x.

(1.) Let $u = \tan x = \frac{\sin x}{\cos x}$, then (art. 12 and 20),

$$du = \frac{d(\sin x)\cos x - d(\cos x)\sin x}{\cos^2 x}$$

$$= \frac{(\cos^2 x + \sin x^2)dx}{\cos^2 x} = \frac{dx}{\cos^2 x}.$$

Hence, again, $du = dx \sec^2 x = dx(1 + \tan^2 x)$.

(2.) In the same way, if $u = \cot x$, we find

$$du = \frac{-dx}{\sin x^2} = -dx \operatorname{cosec}^2 x = -dx(1 + \cot^2 x).$$

(3.) Let $u = \sec x = \frac{1}{\cos x}$; then

$$du = \frac{dx \sin x}{\cos^2 x} = dx \tan x \sec x.$$

(4.) Let $u = \operatorname{cosec} x = \frac{1}{\sin x}$;

$$du = -\frac{dx \cos x}{\sin^2 x} = -dx \cot x \operatorname{cosec} x.$$

23. Corresponding to the direct functions

$u = \sin x$, $u = \cos x$, &c.

there are the reverse functions,

$u = \text{arc}(\sin = x)$, $u = \text{arc}(\cos x)$, &c.

The first, viz. the arc whose sine is x, is sometimes by British writers expressed thus; $u = \sin^{-1}x$; and the second, the arc whose cosine is x, thus; $u = \cos^{-1}x$.

(1.) Let $u = \text{arc}(\sin = x) = \sin^{-1}x$;

then $x = \sin u$; and $dx = du \cos u = du\sqrt{1-x^2}$;

$$\text{and } du = \frac{dx}{\sqrt{1-x^2}}.$$

(2.) Let $u = \text{arc}(\cos = x) = \cos^{-1}x$:

then $x = \cos u$; and $dx = -du \sin u = -du\sqrt{1-x^2}$;

$$\text{and } du = \frac{-dx}{\sqrt{1-x^2}}.$$

(3.) Let $u = \text{arc}(\tan = x) = \tan^{-1}x$:

then $x = \tan u$ and $dx = du(1 + x^2)$;

$$\text{and } du = \frac{dx}{1+x^2}.$$

(4.) Let $u = \text{arc}(\cot = x) = \cot^{-1}x$;

then $x = \cot u$ and $dx = -du(1 + u^2)$,

$$\text{and } du = \frac{-dx}{1+x^2}.$$

(5.) Let $u = \text{arc}(\sec = x) = \sec^{-1}x$;

then $x = \sec u$; and $dx = du \sec u \tan u = du\,x\sqrt{x^2-1}$,

$$\text{and } du = \frac{dx}{x\sqrt{x^2-1}}.$$

(6.) Let $u = \text{arc}(\operatorname{cosec} = x) = \operatorname{cosec}^{-1}x$,

then, proceeding as in the foregoing examples, we find

$$du = \frac{-dx}{x\sqrt{x^2-1}}.$$

24. Having now found rules for the differentiation of the elementary transcendentals and trigonometrical functions, we proceed to exemplify their application to the differentiation of complex functions.

(1.) Let the function be $u = x^y$, that is a variable x raised to a power y, a function of the variable.

By the theory of logarithms $\text{l.}\,u = y\,\text{l.}\,x$.

Put $v = \text{l.}\,u$ and $z = \text{l.}\,x$; then $v = yz$;

and $dv = ydz + zdy$ (art. 10).

Now $dv = d(\text{l.}u) = \frac{du}{u}$; and $dz = d(\text{l.}x) = \frac{dx}{x}$ (20);

$$\text{therefore, } \frac{du}{u} = \frac{ydx}{x} + \text{l.}\,x\,.\,dy,$$

$$\text{and } du \begin{cases} = u\left\{\frac{y}{x}dx + \text{l.}\,x\,.\,dy\right\} \\ = x^y\left\{\frac{y}{x}dx + \text{l.}\,x\,.\,dy\right\} \\ = x^{y-1}\,ydx + x^y\,\text{l.}\,x\,.\,dy. \end{cases}$$

(2.) If $u = x^x$, then, by last example,

$$du = x^x\left\{1 + \text{l.}\,x\right\}dx.$$

(3.) Let $u = a^{b^x}$; put $b^x = y$, then $u = a^y$,

and $du = \text{l.}\,a\;a^y dy$, also $dy = \text{l.}\,b\,.\,b^x\,dx$ (19);

therefore $du = \text{l.}\,a.\,\text{l.}\,b.\,a^{b^x}\,b^x\,dx$.

In the following examples we shall suppose the logarithms to be those of Napier's system.

(4.) Let $u = \text{l.}\left\{\frac{x}{\sqrt{a^2+x^2}}\right\}$. Making $\frac{x}{\sqrt{a^2+x^2}} = z$,

we have $du = \frac{dz}{z}$; but

$$dz = \frac{dx\sqrt{a^2+x^2} - \frac{x^2dx}{\sqrt{a^2+x^2}}}{a^2+x^2} = \frac{a^2dx}{(a^2+x^2)^{\frac{3}{2}}};$$

$$\text{therefore } du = \frac{a^2dx}{x(a^2+x^2)}.$$

(5.) Let $u = \text{l.}\left\{\frac{\sqrt{1+x}+\sqrt{1-x}}{\sqrt{1+x}-\sqrt{1-x}}\right\}$;

put $y = \sqrt{1+x} + \sqrt{1-x}$, $z = \sqrt{1+x} - \sqrt{1-x}$;

then $u = \text{l.}\left(\frac{y}{z}\right) = \text{l.}\,(y) - \text{l.}\,(z)$;

$$\text{and } du = \frac{dy}{y} - \frac{dz}{z}.$$

$$\text{Now } dy = \frac{dx}{2\sqrt{1+x}} - \frac{dx}{2\sqrt{1-x}}$$

$$= \frac{-dx}{2\sqrt{1-x^2}}\left\{\sqrt{1+x} - \sqrt{1-x}\right\} = \frac{-zdx}{2\sqrt{1-x^2}},$$

$$\text{and } dz = \frac{dx}{2\sqrt{1+x}} + \frac{dx}{2\sqrt{1-x}}$$

$$= \frac{dx}{2\sqrt{1-x^2}}\left\{\sqrt{1+x} + \sqrt{1-x}\right\} = \frac{ydx}{2\sqrt{1-x^2}};$$

$$\text{therefore } \frac{dy}{y} - \frac{dz}{z} = \frac{-zdx}{2y\sqrt{1-x^2}} - \frac{ydx}{2z\sqrt{1-x^2}}$$

$$=\frac{-(y^2+z^2)dx}{2yz\sqrt{1-x^2}};$$

and observing that

$$y^2+z^2=4,\quad yz=2x,$$

we find at last $du=\dfrac{-dx}{x\sqrt{1-x^2}}$.

In the next two examples we shall merely put down the results

(6.) $$u=\mathrm{l}.\left\{x+\sqrt{1+x^2}\right\}$$

$$du=\frac{dx}{\sqrt{1+x^2}},$$

(7.) $$u=\mathrm{l}\cdot\left\{\frac{\sqrt{1+x^2}+x}{\sqrt{1+x^2}-x}\right\}^{\frac{1}{2}}$$

$$du=\frac{dx}{\sqrt{1+x^2}}.$$

25. As examples combining logarithmic and angular functions:

(1.) Let $u=\mathrm{l.}\sin x$;

then $du=\dfrac{dx\cos x}{\sin x.}=dx\,\mathrm{cotan}\,x.$

(2.) Let $u=\mathrm{l.}(\tan x)$;

$$du\begin{cases}=\dfrac{dx\sec^2 x}{\tan x}=\dfrac{dx}{\sin x\cos x}\\[2mm] =\dfrac{2dx}{\sin 2x}.\end{cases}$$

26. As examples of complex angular functions:

(1.) Let $u=\tan^{-1}x$; that is, let u be the arc whose tangent is x, and let $z=\cos nu\cos^n u$.

It is proposed to find the differential co-efficient $\dfrac{dz}{dx}$.

In the first place, $du=\dfrac{dx}{\sec^2 u}=dx\cos^2 u$,

$$dz\begin{cases}=-ndu\,(\sin nu\cos^n u+\cos nu\sin u\cos^{n-1}u)\\ =-ndu\cos^{n-1}u\cdot(\sin nu\cos u+\cos nu\sin u)\\ =-ndu\cos^{n-1}u\sin(n+1)u,\end{cases}$$

and $\dfrac{dz}{dx}=-n\sin(n+1)u\cos^{n+1}u.$

(2.) Next, u being the same function of x as before,

let $z=\sin nu\cos^n u$,

to find the differential co-efficient $\dfrac{dz}{dx}$.

In this case,

$$dz\begin{cases}=ndu\,(\cos nu\cos^n u-\sin nu\sin u\cos^{n-1}u)\\ =ndu\cos^{n-1}u\,(\cos nu\cos u-\sin nu\sin u)\\ =ndu\cos^{n-1}u\cos(n+1)u,\end{cases}$$

and $\dfrac{dz}{dx}=n\cos(n+1)u\cos^{n+1}u.$

Successive Differentiations.

27. A function of a variable, when differentiated, produces a new function, viz. its differential co-efficient. This in its turn may be differentiated, and there will be produced another differential co-efficient, which will stand in the same relation to the former as that did to the original function. By another differentiation, a third differential co-efficient may be formed; and so on continually, unless some differential co-efficient come out $=0$.

For example, from the function $u=x^n$, we deduce $\dfrac{du}{dx}=n\,x^{n-1}$: putting now $p=nx^{n-1}$, we hence derive the differential co-efficient $\dfrac{dp}{dx}=n(n-1)x^{n-2}$; and putting $q=n(n-1)x^{n-2}$, we find $\dfrac{dq}{dx}=n(n-1)(n-2)x^{n-3}$. We may proceed in this way, until the result of a differentiation be a constant, and then the process will stop; but in some cases it may be continued indefinitely.

There is an appropriate notation to express the relation in which the successive differentials, p, q, &c. stand to the original function u, from which they have been derived: since

$$p=\frac{du}{dx},\ \text{and}\ q=\frac{dp}{dx},\ \text{therefore}\ q=\frac{d\left(\frac{du}{dx}\right)}{dx}:$$

The symbol $d\left(\dfrac{du}{dx}\right)$ will be more simply expressed by $\dfrac{d^2u}{dx}$; and thus we have

$$p=\frac{du}{dx},\ q=\frac{dp}{dx}=\frac{d^2u}{dx^2};$$

so that by the expression $q=\dfrac{d^2u}{dx^2}$, it is to be understood that q is the result of two differentiations performed on the function u, the differential of the variable, viz. dx, being considered as constant.

From the function q we may now deduce

$$r=\frac{dq}{dx}=\frac{d^3u}{dx^3},$$

and so on continually; but the different import of the characters d^3u and dx^3 must be carefully attended to; the former implies that the operation of differentiation has been performed three times on the function u, and the latter denotes the third power of dx. The combination of the two, $\dfrac{d^3u}{dx^3}$, expresses the function that results from the three differentiations, in each of which the factor dx has been left out, and the final result divided by its third power, or, if retained, that it has been regarded as constant.

(1.) As a particular case of the function $u=ax^n$, let $u=ax^5$;

$$\text{then}\ \frac{du}{dx}=5ax^4,\quad \frac{d^2u}{dx^2}=4\cdot5ax^3,$$
$$\frac{d^3u}{dx^3}=3\cdot4\cdot5ax^2,\quad \frac{d^4u}{dx^4}=2\cdot3\cdot4\cdot5ax,$$
$$\frac{d^5u}{d^5x}=2\cdot3\cdot4\cdot5a.$$

In this example we have come to a differential co-efficient which is a constant, and the series stops; but if the index of the power x^n be a fraction or negative, the series may be continued indefinitely.

The expression $\dfrac{du}{dx}$ is called the *first* differential co-efficient of the function u, or the differential co-efficient of the *first order*; those which follow are called the *second*, *third*, &c. or the differential co-efficients of the *second*, *third*, &c. orders.

In the case of the function $u=x^5$, writers on the calculus of fluxions call $du=5x^4dx$ the *first* fluxion of the function; $d^2u=20x^3dx^2$ its *second* fluxion; $d^3u=60x^2dx^3$ its *third* fluxion; and so on, the terms of the series constituting the different *orders* of fluxions.

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Other examples of successive differentiation:

(2.) Let $u = a^x$; then (article 9), $\frac{du}{dx} = 1.a\,a^x$,

$\frac{d^2u}{dx^2} = (1.a)^2\,a^x$, $\frac{d^3x}{dx^3}\,(1.a)^3\,a^x$, $\frac{d^4x}{dx^4} = (1.a)^4\,a^x$, &c.

(3.) Let $u = \log. x$; then (art. 20) $\frac{du}{dx} = \frac{M}{x}$,

$\frac{d^2u}{dx} = -\frac{M}{x^2}$, $\frac{d^3u}{dx^3} = +\frac{1\cdot 2M}{x^3}$, $\frac{d^4u}{dx^4} = -\frac{1\cdot 2\cdot 3M}{x^4}$, &c.

(4.) Let $u = \sin x$; then $\frac{du}{dx} = \cos x$,

$\frac{d^2u}{dx^2} = -\sin x$, $\frac{d^3u}{dx^3} = -\cos x$, $\frac{d^4u}{dx^4} = \sin x$, &c.

(5.) Let $u = \cos x$; then $\frac{du}{dx} = -\sin x$,

$\frac{d^2u}{dx^2} = -\cos x$, $\frac{d^3u}{dx^3} = \sin x$, $\frac{d^4u}{dx^4} = \cos x$, &c.

(6.) Let $u = \frac{a^2}{a^2 + x^2}$; then $\frac{du}{dx} = \frac{-2a^2x}{(a^2+x^2)^2}$,

$$\frac{d^2u}{dx^2} = \frac{-2a^4 + 6a^2x^2}{(a^2+x^2)^3},$$

$$\frac{d^3u}{dx^3} = \frac{24a^4x - 24a^2x^3}{(a^2+x^2)^4}, \text{ \&c.}$$

Taylor's Theorem.

28. We have assumed for the foundation of the differential calculus an important analytical principle, first particularly recognised by Euler, viz. Let $f(x)$ denote any function of a variable quantity x; if instead of x there be substituted $x + h$, h being any indeterminate quantity, so that the function becomes $f(x + h)$, this new value may always be expanded into a series of this form,

$$f(x) + ph + qh^2 + rh^3 +, \text{\&c.},$$

in which the quantities p, q, &c. are new functions of x derived from the primitive function, and independent of the indeterminate quantity h.

29. The truth of this principle has been exemplified by induction from particular cases. Lagrange has, however, given a demonstration of it in his *Théorie des Fonctions*, which is to the following effect:

In the first place, the development of the function $(x + h)$ cannot contain any fractional power of h, so long as x is entirely indeterminate. For the radicals of h can only come from radicals in the primitive function; and it is manifest that the substitution of $x + h$ instead of x can neither increase nor diminish their number, nor change their nature, while x and h are indeterminate. On the other hand, by the theory of equations, every radical expression has as many different values as there are units in its exponent; from which it follows, that every irrational function has as many distinct values as there are combinations of the different values of the radicals which it contains. Therefore, if the development of the function $f(x + h)$ could contain a term of the form $uh^{\frac{m}{n}}$, the function fx must necessarily be irrational, and contain a certain number of different values, which must be the same for its development; but this development being represented by the series $f(x) + ph + qh^2 +$, &c. $+ uh^{\frac{m}{n}} +$, &c. every value of the function $f(x)$ (the first term) might be combined with each of the n values of the radical $\sqrt[n]{x^m}$, so that the function $f(x + h)$ expanded would have more values than the same function unexpanded, which is impossible.

This demonstration is general and rigorous so long as x and h continue indeterminate; but it fails if determinate values be given to x, for it may happen that these values may destroy some radicals in the function $f(x)$, which may yet exist in the function $f(x + h)$.

30. It being proved that the development of the function cannot have any fractional powers of h, it is easy to be assured that it cannot contain negative powers. For if among the terms one had the form $\frac{r}{h^m}$, m being a positive integer number, then, in making $h = 0$, that term would become infinite, and the function $(x + h)$, and of course $f(x)$, would in this case be infinite, which cannot be, unless a particular value be given to x. Thus it is clearly established that the development of the function can contain neither fractional nor negative exponents.

31. The general form of the development of the function, viz.

$$f(x + h) = f(x) + ph + qh^2 + rh^3 +, \text{\&c.}$$

being thus ascertained, the next question is, what is the law of relation between the original function $f(x)$ and the functions p, q, r, &c. which are derived from it? We owe the discovery of this relation to a celebrated English mathematician, Brooke Taylor, who gave it in his *Methodus Incrementorum*, published in the year 1715 in the form of an analytical theorem, which is now called by his name: we shall now give its investigation. The following is that of Lagrange.

Let $f(x) = u$ be any function of x;
then, supposing x to become $x + h$, u becomes

$$f(x + h) = u + ph + qh^2 + rh^3 + sh^4 +, \text{\&c.}$$

Suppose now that x changes again its value, and becomes $x + k$, and here k, like h, is independent of x. Then

$$f(x + h) \text{ becomes } f(x + h + k).$$

There are two ways of finding what the series

$$f(x + h) = u + ph + qh^2 + rh^3 + sh^4 +, \text{\&c.}$$

becomes, when $x + h$ becomes $x + h + k$. 1*st*, We may have the value of the series by substituting $h + k$ in every term instead of h. 2*dly*, We may also have its value by substituting $x + k$ in the functions p, q, r, s, &c. for x; that is, instead of p, and q, and r, &c. we must put the values they have when $x + k$ is supposed to be substituted in them instead of x.

By the first-mentioned process we find $f(x + h + k) =$

$$\begin{array}{llllll} u + ph + qh^2 & + rh^3 & + sh^4 & +, \text{\&c.} \\ + pk + 2qhk & + 3rh^2k & + 4sh^3k & +, \text{\&c.} \\ \quad + qk^2 & + 3rhk^2 & + 6sh^2k^2 & +, \text{\&c.} \\ & + rk^3 & + 4shk^3 & +, \text{\&c.} \\ & & + sk^4, & +, \text{\&c.} \end{array}$$

And, in employing the second, it must be considered that, when x becomes $x + k$, then

$$u \text{ becomes } u + pk + qk^2 + rk^3 + sk^4 +, \text{\&c.}$$

because k here takes the place of h in the function $f(x + h)$, and its development $u + ph + qh^2 + rh^3 +$, &c.

The supposition that x changes its value to $x + k$, leads to corresponding changes in the functions p, q, r, &c.; so that

$$\begin{array}{ll} p \text{ becomes} & p + p'k + p''k^2 + p'''k^3 +, \text{\&c.} \\ q \quad . \; . \; . & q + q'k + q''k^2 + q'''k^3 +, \text{\&c.} \\ r \quad . \; . \; . & r + r'k + r''k^2 + r'''k^3 +, \text{\&c.} \\ s \quad . \; . \; . & s + s'k + s''k^2 + s'''k^3 +, \text{\&c.} \\ \text{\&c.} & \end{array}$$

Direct Method.

Here p', p'', &c. denote functions of x derived from p, just as p, q, r, &c. are derived from the function u; and a like remark applies to q', q'', &c. also to r', r'', &c. and so on. Substituting now these new values of u, p, q, r, &c. in the series $u + ph + qh^2 + rh^3 + sh^4 +$, &c. we have $f(x + h + k) =$

$$\begin{aligned} u + pk + qk^2 &+ rk^3 + sk^4 +, \text{\&c.} \\ + ph + p'hk &+ p''hk^2 + p'''hk^3 +, \text{\&c.} \\ + qh^2 &+ q'h^2k + q''h^2k^2 +, \text{\&c.} \\ &+ rh^3 + r'h^3k +, \text{\&c.} \\ &+ sh^4 +, \text{\&c.} \end{aligned}$$

By comparing the co-efficients of like powers, or products of powers, of h and k in the two expressions for $f(x + h + k)$, it appears that, to make them identical, we must have

$$2q = p',\ 3r = q',\ 4s = r', \text{ and so on.}$$

$$\text{Therefore } q = \frac{p'}{2}, r = \frac{q'}{3}, s = \frac{r'}{4}, \text{\&c.}$$

Now, by the definition of a differential, pdx is the differential of u, where p is the co-efficient of h in the series $u + ph + qh^2 +$, &c. Therefore $p = \frac{du}{dx}$. Similarly, $q'dx$ is the differential of q, where q' is the co-efficient of k in the development $q - q'k + q''k^2 +$, &c. Therefore, $q' = \frac{dq}{dx}$; and in like manner, $r' = \frac{dr}{dx}$ and $s' = \frac{ds}{dx}$, and so on; hence

$$p = \frac{dy}{dx},$$

$$q = \tfrac{1}{2}p' = \tfrac{1}{2}\frac{dp}{dx} = \frac{1}{1.2}\frac{d^2u}{dx^2},$$

$$r = \tfrac{1}{3}q' = \tfrac{1}{3}\frac{dq}{dx} = \frac{1}{1.2.3}\frac{d^3u}{dx^3},$$

$$s = \tfrac{1}{4}r' = \tfrac{1}{4}\frac{dr}{dx} = \frac{1}{1.2.3.4}\frac{d^4u}{dx^4},$$

&c.

These values of p, q, r, s, &c. being substituted in the series $u + ph + qh^2 + rh^3 + sh^4 +$, &c. we obtain $f(x + h) =$

$$u + \frac{du}{dx}h + \frac{d^2u}{dx^2}\frac{h^2}{1.2} + \frac{d^3u}{dx^3}\frac{h^3}{1.2.3} + \frac{d^4u}{dx^4}\frac{h^4}{1.2.3.4} +, \text{\&c.}$$

where $u = f(x)$; this is Taylor's theorem.

32. We shall now give another investigation of this important formula, which is remarkable for its brevity and simplicity. It rests on the following analytic principle.

If u *be any function whatever of* v + z, *which relation may be expressed thus,* u = f (v + z); *the differential co-efficient of* u, *found on the supposition that* v *is variable and* z *constant, will be the very same as if it were found on the supposition that* z *is variable and* v *constant.*

To exemplify this in particular cases, suppose $u = (v + z)^n$, then, making v variable and z constant, $\frac{du}{dv} = n(v + z)^{n-1}$; and making z variable and v constant, $\frac{du}{dz} = n(v + z)^{n-1}$, the same as before. Again, let $u = a^{v+z} = a^v\ a^z$, then $\frac{du}{dv}$ and $\frac{du}{dz}$ are expressed by the same quantity $1.a.a^v\ a^z = 1.a.a^{v+z}$.

The truth of the principle is almost self-evident; for if we make $v + z = x$, so that $f(v + z) = f(x)$; then, whether we suppose v to vary and to become $v + h$, while z remains the same, or z to vary and become $z + h$, while v remains constant, the result is the very same, viz.

$$f(v + z + h) = f(x + h);$$

therefore, in the development of $f\ (v + z + h) = f(x + h)$, viz.

$$f(x) + ph + qh^2 + rh^3 +, \text{\&c.}$$

in which p, q, &c. are functions of x; that is, of $v + z$, these functions will be the very same, whichever of the two, v and z, has been considered as the variable, the other remaining constant. Now, by the nature of a differential (art. 7), we have

$$p = \frac{d\{f(x)\}}{dx} = \frac{d\{f(v + z)\}}{d(v + z)};$$

and upon the supposition that v is variable and z constant, then

$$p = \frac{d\{f(v + z)\}}{dv};$$

but supposing z variable and v constant,

$$p = \frac{d\{f(v + z)\}}{dz};$$

$$\text{therefore } \frac{d\{f(v + z)\}}{dv} = \frac{d\{f(v + z)\}}{dz};$$

the first side of this equation being the result of the differentiation, supposing v variable, and the second the result, on the hypothesis that z is variable. Since the two expressions $\frac{d\{f(v + z)\}}{dv}$ and $\frac{d\{(v + z)\}}{dz}$ are identical and the same function of $v + z$, we may represent that function by the symbol $\mathrm{F}(v + z)$; then, by reasoning as before, we shall have

$$\frac{d\{\mathrm{F}(v + z)\}}{dv} = \frac{d\{\mathrm{F}(v + z)\}}{dz},$$

$$\text{that is, } \frac{d^2\{f(v + z)\}}{dv^2} = \frac{d^2\{f(v + z)\}}{dz^2}.$$

Thus it appears that the second differential co-efficient of the function $f(v + z)$ is the same expression, whether v or z be regarded as the variable; and the reasoning may be extended to the co-efficient of any order.

33. Supposing now $f(x) = u$ to be any function of x, and $f(x + h) = u'$ to be its value when x becomes $x + h$, it has been proved (art. 29, 30), that the expansion of u is

$$u' = u + ph + qh^2 + rh^3 + sh^4;$$

and here p, q, r, &c. are functions of x, into which x does not at all enter; while, on the other hand, h is entirely independent of x. From the identity of the function u' and its expansion, their differentials, taken on the same hypothesis, must be equal, whichever of the quantities x and h be regarded as the variable. Supposing, first, x variable and h constant, we have

$$\frac{du'}{dx} = \frac{du}{dx} + \frac{dp}{dx}h + \frac{dq}{dx}h^2 + \frac{dr}{dx}h^3 + \frac{ds}{dx}h^4 +, \text{\&c.}$$

and next, supposing h to be variable and x constant,

$$\frac{du}{dh} = p + 2qh + 3rh^2 + 4sh^3 +, \text{\&c.}$$

Now it has been shown in last article that $\frac{du'}{dx} = \frac{du'}{dh}$; therefore the series which are their expansions must be identical; and hence the terms independent of h must be equal, also the co-efficients of the same power of h, so that

$$p = \frac{du}{dx},\quad 2q = \frac{dp}{dx},\quad 3r = \frac{dq}{dx},\quad 4s = \frac{dr}{dx}, \text{\&c.};$$

and since $p=\frac{du}{dx}$, therefore $q=\frac{1}{2}\frac{dp}{dx}=\frac{1}{2}\frac{d^2u}{dx^2}$, and $r=\frac{1}{3}\frac{dq}{dx}=\frac{1}{2.3}\frac{d^3u}{dx^3}$; also $s=\frac{1}{4}\frac{dr}{dx}=\frac{1}{2.3.4}\frac{d^4u}{dx^4}$, &c.; and, on the whole, $f(x+h)=$

$$u'=u+\frac{du}{dx}h+\frac{d^2u}{dx^2}\frac{h^2}{2}+\frac{d^3u}{dx^3}\frac{h^3}{2.3}+\frac{d^4u}{dx^4}\frac{h^4}{2.3.4}+, \&c.$$

From this formula it appears, that if h be the increment of the variable x; the whole increment of u, any function of x, is

$$u'-u=\frac{du}{dx}\frac{h}{1}+\frac{d^2u}{dx^2}\frac{h^2}{1.2}+\frac{d^3u}{dx^3}\frac{h^3}{1.2.3}+, \&c.$$

a series composed of the successive differential co-efficients of the function, each multiplied by an integer power of h, and divided by the products 1, 1.2, 1.2.3, &c.

Application of Taylor's Theorem to the Development of Functions.

We shall now give some applications of this most important analytic formula to the development of functions.

34. Let the function $f(x)$ be $u=x^n$, so that $f(x+h)=(x+h)^n$. By successive differentiation (art. 13 and 27),

$$\frac{du}{dx}=nx^{n-1},\ \frac{d^2u}{dx^2}=n(n-1)x^{n-2},\ \frac{d^3u}{dx^3}=n(n-1)(n-2)x^{n-3},$$

$$\frac{d^4u}{dx^4}=n(n-1)(n-2)(n-3)x^{n-4}, \&c.$$

These differential co-efficients, when substituted in the formula, give

$$(x+h)^n=x^n+nx^{n-1}h+\frac{n(n-1)}{1.2}x^{n-2}h^2+\frac{n(n-1)(n-2)}{1.2.3}x^{n-3}h^3+, \&c.$$

This is the well-known binomial theorem (ALGEBRA, art. 160).

35. Next, let $f(x)$ be $u=a^x$, a variable power of the constant quantity a. Then, putting

$$A=(a-1)-\tfrac{1}{2}(a-1)^2+\tfrac{1}{3}(a-1)^3-\tfrac{1}{4}(a-1)^4+, \&c.$$

By article 19, $\frac{du}{dx}=Aa^x$, $\frac{d^2u}{dx^2}=A^2a^x$, $\frac{d^3u}{dx^3}=A^3a^x$,

$$\frac{d^4u}{dx^4}=A^4a^x, \&c.$$

Remarking now that $f(x+h)=a^{x+h}=a^x\,a^h$, we have

$$a^x\,a^h=a^x\left\{1+Ah+\frac{A^2h^2}{1.2}+\frac{A^3h^3}{1.2.3}+\frac{A^4h^4}{1.2.3.4}+, \&c.\right\};$$

and dividing both sides by a^x, and changing h into x,

$$a^x=1+Ax+\frac{A^2x^2}{1.2}+\frac{A^3x^3}{1.2.3}+\frac{A^4x^4}{1.2.3.4}+, \&c.$$

If we suppose $x=1$, then,

$$a=1+A+\frac{A^2}{1.2}+\frac{A^3}{1.2.3}+\frac{A^4}{1.2.3.4}+, \&c.$$

and if we make $x=\frac{1}{A}$, we have

$$a^{\frac{1}{A}}=1+1+\frac{1}{1.2}+\frac{1}{1.2.3}+\frac{1}{1.2.3.4}+, \&c.$$

Hence it appears that $a^{\frac{1}{A}}$ is a constant number, which is the sum of this series. By taking the sum of a sufficient number of its terms, we find

$$a^{\frac{1}{A}}=2{\cdot}718281828459.$$

Let this number, which will frequently recur, be denoted by the letter e, and we have

$$a^{\frac{1}{A}}=e, \text{ and } a=e^A \text{ and}$$

$$e^{Ax}=a^x=1+Ax+\frac{A^2x^2}{1.2}+\frac{A^3x^3}{1.2.3}+\frac{A^4x^4}{1.2.3.4}+, \&c.;$$

and making $y=Ax$, so that y may be any number,

$$e^y=1+y+\frac{y^2}{1.2}+\frac{y^3}{1.2.3}+\frac{y^4}{1.2.3.4}+, \&c.$$

This formula expresses a remarkable property of the number e.

36. Let the function $f(x)$ be $u=\log x$ to base a, then, by article 20,

$$\frac{du}{dx}=\frac{1}{Ax},\ \frac{d^2u}{dx^2}=\frac{-1}{Ax^2},\ \frac{d^3u}{dx^3}=\frac{1.2}{Ax^3}, \&c.$$

$$\frac{d^4u}{dx^4}=-\frac{1.2.3}{Ax^4},\ \frac{d^5u}{dx^5}=\frac{1.2.3.4.5}{Ax^5}, \&c.$$

Hence, by the theorem, $f(x+h)=\log(x+h)=\log x+\frac{1}{A}\left\{\frac{h}{x}-\frac{h^2}{2x^2}+\frac{h^3}{3x^3}-\frac{h^4}{4x^4}+\frac{h^5}{5x^5}-, \&c.\right\}$.

Make $x=1$, and observe that $\log 1=0$, and change h into x, and we have

$$\log(1+x)=\frac{1}{A}\left\{x-\tfrac{1}{2}x^2+\tfrac{1}{3}x^3-\tfrac{1}{4}x^4+, \&c.\right\}$$

This is the logarithm of $1+x$ in the system whose base is a.

In the preceding article we found that $a=e^A$, hence, from the theory of logarithms (ALGEBRA, sect. xix.), A is the logarithm of a to the base e. Now

$$A=a-1-\tfrac{1}{2}(a-1)^2+\tfrac{1}{3}(a-1)^3-\tfrac{1}{4}(a-1)^4,+, \&c.$$

Therefore, in the system whose base is e,

$$\log a=a-1-\tfrac{1}{2}(a-1)^2+\tfrac{1}{3}(a-1)^3-\tfrac{1}{4}(a-1)^4;$$

and hence, putting $1+x$ for a, and x for $a-1$, in that system,

$$\log(1+x)=x-\tfrac{1}{2}x^2+\tfrac{1}{3}x^3-\tfrac{1}{4}x^4+, \&c.$$

Now we found that in the system whose base is a,

$$\log(1+x)=\frac{1}{A}\{x-\tfrac{1}{2}x^2+\tfrac{1}{3}x^3-\tfrac{1}{4}x^4+, \&c.\}$$

By comparing these two expressions for $\log(1+x)$, it appears that in the system whose base is e, the constant quantity A, which is

$$e-1-\tfrac{1}{2}(e-1)^2+\tfrac{1}{3}(e-1)^3-\tfrac{1}{4}(e-1)^4+, \&c.$$

is equal to unity. Logarithms computed according to this system are the same as those first given to the world by Napier, the celebrated inventor of logarithms, who was, however, led to them by a very different path from that here followed. It so happens that the same logarithms express hyperbolic areas, and hence they were called *hyperbolic* logarithms, a distinction quite improper, because hyperbolic areas may be expressed by logarithms of any system. Accordingly, it is now common to denominate them, in honour of the inventor, *Napierian* logarithms. In speaking of these, then, it must be understood that their base is $e=2{\cdot}718281828459$, &c.; and remembering that the letter l prefixed to any expression of a function means *Napier's logarithm* of that function (art. 19).

$$\mathrm{l.}(1+x)=x-\tfrac{1}{2}x^2+\tfrac{1}{3}x^3-,\tfrac{1}{4}x^4+, \&c.$$

and since $A=$ Nap. $\log a$ (see last article), therefore in the system whose base is a,

$$\log(1+x)=\frac{1}{\mathrm{l.}a}\{x-\tfrac{1}{2}x^2+\tfrac{1}{3}x^3-\tfrac{1}{4}x^4+, \&c.\}$$

The constant multiplier $\frac{1}{1.\,a}$, called the *modulus* of the system, is, for Briggs's logarithms,

$\frac{1}{1.(10)} = \cdot 4342944819033$ —, and its reciprocal,

$1.(10) = 2\cdot 302585092994$.

37. Let the function be $fx = u = \sin x$, then

$$\frac{du}{dx} = +\cos x, \frac{d^2u}{dx^2} = -\sin x, \frac{d^3u}{dx^3} = -\cos x,$$

$$\frac{d^4u}{dx^4} = +\sin x, \frac{d^5u}{dx^5} = +\cos x, \&c.$$

These values of the differential co-efficients being substituted in the theorem, it gives $f(x+h) = \sin(x+h)$

$$= \sin x + \cos x\frac{h}{1} - \sin x\frac{h^2}{1.2} - \cos x\frac{h^3}{1.2.3} + \sin x\frac{h^4}{1.2.3.4} +, \&c.$$

$$= \begin{cases} \sin x\left(1 - \frac{h^2}{2} + \frac{h^4}{2.3.4} - \frac{h^6}{2.3.4.5.6} +, \&c.\right) \\ +\cos x\left(h - \frac{h^3}{2.3} + \frac{h^5}{2.3.4.5} - \frac{h^7}{2.3.4.5.6.7} +, \&c.\right) \end{cases}$$

Let the function be $fx = u = \cos x$, then

$$\frac{du}{dx} = -\sin x, \frac{d^2u}{dx^2} = -\cos x, \frac{d^3u}{dx^3} = \sin x,$$

$$\frac{d^4u}{du^4} = \cos x, \frac{d^5u}{dx^5} = -\sin x, \&c.$$

and by substituting in the formula $f(x+h) = \cos(x+h)$

$$= \cos x - \sin x\frac{h}{1} - \cos x\frac{h^2}{2} + \sin x\frac{h^3}{2.3} + \cos x\frac{h^4}{2.3.4} -, \&c.$$

$$= \begin{cases} \cos x\left(1 - \frac{h^2}{2} + \frac{h^4}{2.3.4} - \frac{h^6}{2.3.4.5.6} +, \&c.\right) \\ -\sin x\left(h - \frac{h^3}{2.3} + \frac{h^5}{2.3.4.5} - \frac{h^7}{2.3.4.5.6.7} +, \&c.\right) \end{cases}$$

Put $P = 1 - \frac{h^2}{2} + \frac{h^4}{2.3.4} - \frac{h^6}{2.3.4.5.6} +, \&c.$

$Q = h - \frac{h^3}{2\cdot 3} + \frac{h^5}{2.3.4.5} - \frac{h^7}{2.3.4.5.6.7} +, \&c.$

Then $\sin(x+h) = P\sin x + Q\cos x$,

$\cos(x+h) = P\cos x - Q\sin x$.

Hence, by eliminating Q and P in succession,

$\sin(x+h)\sin x + \cos(x+h)\cos x = P$,

$\sin(x+h)\cos x - \cos(x+h)\sin x = Q$.

Therefore (ALGEBRA, 239), $\cos h = P$, $\sin h = Q$; and exchanging h for x,

$$\cos x = 1 - \frac{x^2}{2} + \frac{x^4}{2.3.4} - \frac{x^6}{2.3.4.5.6} +, \&c.$$

$$\sin x = x - \frac{x^3}{2.3} + \frac{x^5}{2.3.4.5} - \frac{x^7}{2.3.4.5.6.7} +, \&c.$$

The same results might have been obtained easier by making $x = 0$ in the series for $\sin(x+h)$ and $\cos.(x+h)$.

38. Let the function be the arc whose tangent is x, that is, $u = \tan^{-1} x$;

then $du = \frac{dx}{1+x^2} = dx\cos^2 u$ (art. 23),

and $\frac{du}{dx} = \cos u \cos u$,

The succeeding differential co-efficients will be found by formulæ (1) and (2) of article 26.

By (1) $\frac{d^2u}{dx^2} = -\sin 2u\cos^2 u$,

By (2) $\frac{d^3u}{dx^3} = -2\cos 3u\cos^3 u$,

By (1) $\frac{d^4u}{dx^4} = 2.3\sin 4u\cos^4 u$,

By (2) $\frac{d^5u}{dx^5} = 2.3.4\cos 5u\cos^5 u$,

By (1) $\frac{d^6u}{dx^6} = 2.3.4.5\sin 6u\cos^6 u$,

By (2) $\frac{d^7u}{dx^7} = -2.3.4.5.6\cos 7u\cos^7 u$, &c.

Hence, if we put $\tan u = x$, and $\tan u' = x+h$, we deduce from Taylor's theorem this very general and remarkable formula:

$$u' = u + \cos u\cos u\frac{h}{1} - \sin 2u\cos^2 u\frac{h^2}{2} - \cos 3u\cos^3 u\frac{h^3}{3}$$

$$+ \sin 4u\cos^4 u\frac{h^4}{4} + \cos 5u\cos^5 u\frac{h^5}{5}$$

$$- \sin 6u\cos^6 u\frac{h^6}{6} -, \&c.$$

If the arc u be supposed $= 0$, then $\sin u$, $\sin 2u$, &c. are each 0, and the powers of $\cos u$ each $= 1$, and the formula becomes

$$u = \tan u - \frac{1}{3}\tan^3 u + \frac{1}{5}\tan^5 u - \frac{1}{7}\tan^7 u +, \&c.$$

a formula due to James Gregory. We have found this series in a very different way (ALGEBRA, art. 270), and have there applied it to the determination of the ratio of the diameter to the circumference. It will be therefore sufficient to state the result here. Let π denote half the circumference of a circle, of which the rad. $= 1$, then

$\pi = 3\cdot 141592653590$—.

Maclaurin's Theorem.

39. There is a general formula nearly related to that of Taylor, and indeed an easy deduction from it, commonly called *Maclaurin's Theorem.* It is given at page 610 of the second volume of his fluxions (printed in 1742); but it is proper to say, that the same formula, in substance, was given in 1717 by Stirling, in his *Lineæ Tertii Ordines Neutonianæ*, p. 32.

We have found that $f(x) = u$ being any function of a variable x,

$$f(x+h) = u + \frac{du}{dx}h + \frac{d^2u}{dx^2}\frac{h^2}{2} + \frac{d^3u}{dx^3}\frac{h^3}{2.3} + \frac{d^4u}{dx^4}\frac{h^4}{2.3.4} +, \&c.$$

Suppose now that $x = 0$, and that by making this assumption

$f(x) = u$ becomes U,

also that $\frac{du}{dx}$ becomes U',

$\frac{d^2u}{dx^2}$ .... U'',

$\frac{d^3u}{dx^3}$ .... U''',

&c.

Then Taylor's theorem becomes

$$f(h) = U + U'h + U''\frac{h^2}{1.2} + U'''\frac{h^3}{1.2.3} +, \&c.$$

or, changing h into x,

$$f(x) = U + U'x + U''\frac{x^2}{1.2} + U'''\frac{x^3}{1.2.3} +, \&c.$$

From this it appears, that provided u be such a function of x as admits of being expanded into a series of the form

$$u = A + Bx + Cx^2 + Dx^3 +, \&c.$$

where A, B, C, D, &c. are constant quantities, then, U being the value of u when $x = 0$, and U', U'', U''', &c. be-

ing the values of the differential co-efficients $\frac{du}{dx}, \frac{d^2u}{dx^2}, \frac{d^3u}{dx^3}$, &c. found on that hypothesis, we have

$$A = U, B = U', C = U'', D = U''', \&c.$$

and consequently,

$$u = U + U'x + U''\frac{x^2}{2} + U'''\frac{x^3}{2 . 3} +, \&c.$$

This is Maclaurin's theorem, of which we shall now give some applications.

40. Let $u = (a + x)^n$. The expression of this expression has the requisite form; then $\frac{du}{dx} = n(a + x)^{n-1}$,

$$\frac{d^2u}{dx^2} = n(n-1)(a+x)^{n-2},$$

$$\frac{d^3u}{dx^3} = n(n-1)(n-2)(a+x)^{n-3}, \&c.$$

The supposition that $x = 0$ makes

$$u = a^n = U, \frac{du}{dx} = na^{n-1} = U', \frac{d^2x}{dx^2} = n(n-1)a^{n-2} = U'',$$

$$\frac{d^3u}{dx^3} = n(n-1)(n-2)a^{n-3} = U''', \&c.$$

The proper substitutions being made in the general theorem, we have

$$(a + x)^n = a^n + na^{n-1}x + \frac{n(n-1)}{1 . 2}a^{n-2}x^2 + \frac{n(n-1)(n-2)}{1 . 2 . 3}a^{n-3}x^3 +, \&c.$$

41. Let $u = a^x$. This function is also of the kind that admits of expansion by the theorem; the differential co-efficients are (art. 19), putting $A = l. a$,

$$\frac{du}{dx} = Aa^x, \frac{d^2u}{dx^2} = A^2a^x, \frac{d^3u}{dx^3} = A^3a^x, \&c.$$

The supposition that $x = 0$ gives $u = 1$, and

$$\frac{du}{dx} = A, \frac{d^2u}{dx^2} = A^2, \frac{d^3u}{dx^3} = A^3, \&c.$$

Hence $a^x = 1 + Ax + \frac{A^2x^2}{1 . 2} + \frac{A^3x^3}{1 . 2 . 3} +, \&c.$

as was found in art. 35.

42. The formula $u = \log x$ does not admit of being expanded into a series of the prescribed form, for in this case $\frac{du}{dx} = \frac{1}{Ax}$; the supposition that $x = 0$ makes u and $\frac{du}{dx}$, as well as all the following differential co-efficients, infinite. The function $u = \log(n + x)$, however, admits of the application of the formula. In this case (art. 20),

$$\frac{du}{dx} = \frac{1}{A(n + x)}, \frac{d^2u}{dx^2} = \frac{-1}{A(n+x)^2}, \frac{d^3u}{dx^3} = \frac{1 . 2}{A(n+x)^3}, \&c.$$

The assumption that $x = 0$ makes $u = \log n = U$, and

$$\frac{du}{dx} = \frac{1}{An} = U', \frac{d^2u}{dx^2} = -\frac{1}{An^2} = U'', \frac{d^3u}{dx^3} = \frac{1 . 2}{An^3} = U''', \&c.$$

We have now, by the general formula,

$$\log(n + x) = \log n + \frac{1}{A}\left\{\frac{x}{n} - \frac{x^2}{2n} + \frac{x^3}{3n} -, \&c.\right\}.$$

By making $n = 1$, and therefore $\log n = 0$, we have the expression for $\log(1 + x)$, as already found.

43. The theorem may be applied to the functions $u = \sin x$, and $u = \cos x$, without the least difficulty. For the first we have

$$U = 0, \quad U' = 1, \quad U'' = 0, \quad U''' = -1, \&c.$$

and $\sin x = x - \frac{x^3}{1 . 2 . 3} + \frac{x^5}{1 . 2 . 3 . 4 . 5} +, \&c.$;

for the second function

$$U = 1, \quad U' = 0, \quad U'' = -1, \quad U''' = 0, \&c.$$

$$\cos x = 1 - \frac{x^2}{1 . 2} + \frac{x^4}{1 . 2 . 3 . 4} - \frac{x^6}{1 . 2 . 3 . 4 . 5 . 6} +, \&c.$$

44. Let u denote the arc whose sine is x; that is, let $u = \sin^{-1} x$. In this case (23),

$$\frac{du}{dx} = (1 - x^2)^{-\frac{1}{2}},$$

$$\frac{d^2u}{dx^2} = x(1 - x^2)^{-\frac{3}{2}},$$

$$\frac{d^3u}{dx^3} = (1 - x^2)^{-\frac{3}{2}} + 3x^2(1 - x^2)^{-\frac{5}{2}},$$

$$\frac{d^4u}{dx^4} = 3 . 3x(1 - x^2)^{-\frac{5}{2}} + 3 . 5x^3(1 - x^2)^{-\frac{7}{2}},$$

&c.

Making $x = 0$ we get $U = 0$, $U' = 1$, $U'' = 0$, $U''' = 1$, $U^{IV} = 0$; and, by continuing the process of differentiation, $U^{V} = 3 . 3$, &c. therefore

$$u = x + \frac{x^3}{1 . 2 . 3} + \frac{3 . 3x^5}{1.2.3.4.5} + \frac{3^2 . 5^2x^7}{1.2.3.4.5.6.7} +, \&c.$$

Cases in which Taylor's Theorem fails.

45. We have seen that Taylor's theorem, viz. $u = f(x)$ being any function of a variable x,

$$f(x+h) = u + \frac{du}{dx}\frac{h}{1} + \frac{d^2u}{dx^2}\frac{h^2}{1 . 2} + \frac{d^3u}{dx^3}\frac{h^3}{1.2.3} +, \&c.$$

will always hold true, provided that the variable x be regarded as indeterminate. If however particular values be given to x, there are cases in which the development is of no use, because in these cases it is not applicable to the function.

For example, let $u = b + (x - a)^{\frac{1}{2}}$; in this case,

$$\frac{du}{dx} = \frac{1}{2(x - a)^{\frac{1}{2}}}, \frac{d^2u}{dx^2} = -\frac{1}{4(x - a)^{\frac{3}{2}}}, \&c.$$

and by the theorem,

$$f(x + h) = b + (x - a + h)^{\frac{1}{2}} = b + (x - a)^{\frac{1}{2}} + \frac{1}{2(x - a)^{\frac{1}{2}}}h - \frac{1}{8(x - a)^{\frac{3}{2}}}h^2 +, \&c.$$

Now if we give to x any particular value greater than a, the development is perfectly significant, and expresses truly the value of $b + (x - a + h)^{\frac{1}{2}}$. If however we give to x the particular value a, then $x - a = 0$, and the development becomes $b + 0 + \frac{h}{2(0)^{\frac{1}{2}}} - \frac{h^2}{8(0)^{\frac{3}{2}}} +, \&c.$ from which no conclusion whatever can be drawn, because all the terms having *zero* in the denominator are infinite. If in the expression $b + (x - a + h)^{\frac{1}{2}}$ we make $x = a$, it becomes $b + h^{\frac{1}{2}}$. This expression has two values, viz. $b + \sqrt{h}$, $b - \sqrt{h}$. The development given by the theorem contains, however, only positive integer powers of h; therefore it can have only a single value; and hence it is impossible that it should express the function in the particular case of $x = a$. In such cases the theorem has been said to *fail*; this however happens not from any imperfection in the theorem, but merely because it is unsuitable to the purpose to which it has been applied; and this want of applicability is indicated by the co-efficients of the powers of h failing to express any thing definite.

46. Again, let the function be $u = \frac{b}{(x - a)^2}$; then

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$$\frac{du}{dx} = -\frac{2b}{(x-a)^3}, \frac{d^2u}{dx^2} = \frac{6b}{(x-a)^4}, \text{ \&c.}$$

In this case

$$f(x+h) = \frac{b}{(x-a+h)^2} = \frac{b}{(x-a)^2} - \frac{2b}{(x-a)^3}h + \frac{3b}{(x-a)^4}h^2 -, \text{ \&c.}$$

Here x may have any particular value greater or less than a, and the development will be perfectly significant; if, however, x be equal to a, it becomes

$$\frac{b}{(o)^2} - \frac{2\,b}{(o)^3}h + \frac{3\,b}{(o)^4}h^2 -, \text{ \&c.};$$

an expression that has no meaning, because each of the co-efficients of h is infinite.

If we make $x = a$ in $\frac{b}{(x-a+h)^2}$, the function to be expanded, it becomes $\frac{b}{h^2} = bh^{-2}$, an expression in which the exponent of h is negative; therefore this case cannot be included in a formula which contains only positive integers of h, and hence the apparent failure of the theorem.

47. That a general formula should not express all particular cases, was at one time regarded as a kind of paradox in analysis. Lagrange first cleared up this point, and showed, that when by giving particular values to x, the new state of the function contains terms of the form Ph^{-n}, or $Qh^{\frac{m}{n}}$, that is, negative or fractional powers of h, then, from the very nature of the calculus, all the co-efficients in the general development after a certain term will become infinite. On the other hand, when a particular value of x renders the co-efficients infinite, we may conclude that the development in that case ought to contain fractional or negative powers of h. In such particular cases as appear not to admit of expansion by Taylor's theorem, other methods deducible from the calculus are applicable; in general, the ordinary algebraic methods are sufficient.

Differentiation of Equations of two Variables.

48. We have as yet differentiated only equations in which the variables were separated, such as this, $y = a + b\,x + cx^2$, where y is an explicit function of x. But the equations which chiefly occur in analytical inquiries contain for the most part the two variables combined or mixed together; as in this equation,

$$y^2 - 2\,mxy + x^2 - a^2 = 0.$$

If we suppose the equation resolved, so that y is expressed in terms of x only, which gives

$$y = mx \pm \sqrt{a^2 + (m^2-1)\,x^2},$$

the differentials may be found by the rules already explained. In general, however, the variables cannot be so separated, and therefore it is necessary that we be able to determine the differential co-efficients of a function by other means.

49. An equation formed in any way from two independent variable quantities may be represented by the general symbol

$$f(x, y) = 0.$$

The variable y must be expressible in some way by x; therefore we may represent its value, however found, by the equation $y = X$, where X denotes an expression made up of terms containing only x and constant quantities. When this value of y is substituted in the equation, it becomes

$$f(x, X) = 0.$$

This is an identical equation, involving x only, which must hold true whatever value be given to x. Let the expression $f(x, X) = f(x, y)$ be denoted briefly by u. Suppose now x to change its value and become $x + h$; by Taylor's theorem, its new values will be

$$u' = u + \frac{du}{dx}h + \frac{d^2u}{dx^2}h^2 + \frac{d^3u}{dx^3}h^3 +, \text{ \&c.}$$

The equation $f(x, y) = u = 0$ must hold true whatever value be given to x; therefore we must have $u' = 0$, and this requires that the co-efficients of the different powers of the indeterminate quantity h be separately $= 0$ (art. 18), so that from the equation $u = f(x, y) = 0$ there may be derived a series of equations,

$$\frac{du}{dx} = 0, \frac{d^2u}{dx^2} = 0, \frac{d^3u}{dx^3} = 0, \text{ \&c.}$$

which must all hold true at the same time as the original equation.

50. Let us take for example the equation

$$y^2 + x^2 = a^2, \text{ or } y^2 + x^2 - a^2 = 0 \ldots\ldots\ldots(1.)$$

in which a is a constant quantity; in this case,

$$u = y^2 + x^2 - a^2;$$

hence we have by differentiation

$$\frac{du}{dx} = 2\,y\frac{dy}{dx} + 2\,x = 0,$$

$$\text{and } \frac{dy}{dx} = -\frac{x}{y} \ldots\ldots\ldots\ldots\ldots\ldots(2.).$$

To determine the differential co-efficient of the second order, put $\frac{dy}{dx} = p$, and we have

$$\frac{du}{dx} = 2\,yp + 2\,x;$$

as p is a function of x and y, and y is a function of x, therefore p is a function of x. Taking now the differentials, and dividing by dx, the result is

$$\frac{d^2u}{dx^2} = 2\left(y\frac{dp}{dx} + p\frac{dy}{dx} + 1\right) = 0;$$

hence, because $p = \frac{dy}{dx}$, and $\frac{dp}{dx} = \frac{d^2y}{dx^2}$,

$$\frac{d^2u}{dx^2} = 2\left(y\frac{d^2y}{dx^2} + \frac{dy^2}{dx^2} + 1\right) = 0 \ldots\ldots\ldots\ldots(3.)$$

From this equation we get

$$\frac{d^2y}{dx^2} = -\frac{1}{y}\left(\frac{dy^2}{dx^2} + 1\right),$$

$$\text{or, since } \frac{dy}{dx} = -\frac{x}{y},$$

$$\frac{d^2y}{dx^2} = -\frac{x^2}{y^3} - \frac{1}{y} \ldots\ldots\ldots\ldots(4.)$$

To find the differential co-efficient of the third order, we put $\frac{d^2y}{dx^2} = \frac{dp}{dx} = q$; and substituting p for $\frac{dy}{dx}$ in equation (3), it becomes

$$\frac{d^2u}{dx^2} = 2\,(yq + p^2 + 1) = 0;$$

observing that p and q are functions of x and y, and consequently of x, we may find by differentiation an expression which will involve, besides x and y, these quantities,

$$\frac{dq}{dx}, \frac{dp}{dx} = \frac{d^2y}{dx^2}, q = \frac{d^2y}{dx^2}, p = \frac{dy}{dx};$$

and from this equation $\frac{dq}{dx} = \frac{d^3y}{dx^3}$ may be determined, observing that $\frac{d^2y}{dx^2}$ and $\frac{dy}{dx}$ are expressed by x and y in equations (4) and (2).

51. The preceding analysis gives the following rule for

determining the differential co-efficients of y, a function of x, when the relation between x and y is expressed by an equation.

Take the differentials of the terms of the equation, considering y as a function of x, and dividing by dx, the result will be an equation which gives the value of $\frac{dy}{dx}$. Again, take the differentials of the terms of this equation, considering y and $\frac{dy}{dx}$ as functions of x, and the result will be an equation involving $\frac{d^2y}{dx^2}$ and $\frac{dy}{dx}$, which, combined with the former, serves to determine $\frac{d^2y}{dx^2}$. A third equation may be found from this, by taking the differentials, and considering y, $\frac{dy}{dx}$, and $\frac{d^2y}{dx^2}$, as functions of x; and this, combined with the other two, gives $\frac{d^3y}{dx^3}$, and so on to any number of equations.

Let y be such a function of x that

$$y^2 - 2\,mxy + x^2 - a^2 = 0 \quad \ldots\ldots\ldots\ldots (1.)$$

It is proposed to determine its differential co-efficients.

By a first differentiation

$$(y - mx)\,dy - (my - x)\,dx = 0,$$

$$\text{and } \frac{dy}{dx} = \frac{my - x}{y - mx} \quad \ldots\ldots\ldots\ldots (2.)$$

Again, by differentiating,

$$\frac{d^2y}{dx^2} = \frac{(1 - m^2)x}{(y - mx)^2} \cdot \frac{dy}{dx} - \frac{(1 - m^2)y}{(y - mx)^2} \ldots\ldots (3.)$$

and, substituting for $\frac{dy}{dx}$ its value,

$$\frac{d^2y}{dx^2} = -(1 - m^2)\frac{y^2 - 2\,mxy + x^2}{(y - mx)^3} = \frac{-(1 - m^2)a^2}{(y - mx)^3} (4.)$$

If we take the differentials of both sides of equation (3), and consider $\frac{dy}{dx}$, $\frac{d^2y}{dx^2}$, as functions of x, we shall obtain

$$\frac{d^3y}{dx^3} = \mathrm{P}\frac{d^2y}{dx^2} + \mathrm{Q}\frac{dy}{dx} + \mathrm{R} \ldots\ldots\ldots\ldots (5.)$$

Here P, Q, R, denote expressions composed of y and x. By substituting for $\frac{d^2y}{dx^2}$ and $\frac{dy}{dx}$ their values as given by equations (4) and (2), there will be obtained the value of $\frac{d^3y}{dx^3}$, in terms of x and y.

52. The equations which may be deduced by differentiation from a proposed equation are called *fluxional* or *differential* equations, and the equation from which they have been deduced is called the *primitive* equation. The equation which gives the value of $\frac{dy}{dx}$ is said to be of the *first order*, and that which involves $\frac{d^2y}{dx^2}$ is of the *second order*, and so on for the higher orders.

Thus, the primitive equation being

$$y^2 - 2mxy + x^2 - a^2 = 0,$$

we have found, for the differential equation of the first order,

$$\frac{dy}{dx} - \frac{my - x}{y - mx} = 0;$$

and that of the second order,

$$\frac{d^2y}{dx^2} - \frac{(1 - m^2)x}{(y - mx)^2} \cdot \frac{dy}{dx} + \frac{(1 - m^2)y}{(y - mx)^2} = 0,$$

equivalent to $\frac{d^2y}{dx^2} + (1 - m^2)\frac{y^2 - 2mxy + x^2}{(y - mx)^3} = 0.$

53. Differential equations of all orders hold true simultaneously with the primitive from which they have been derived, therefore any combination of them will also hold true; and whatever number of values the function y has (in the preceding example it has two), the differential co-efficients into which y enters will have the same number.

It has appeared (art 15) that in functions of a certain form the constants they contain vanish from their differentials. A like remark applies to differential equations. Thus, if $y^2 = ax + b$ be a primitive equation, in which a and b are constants, the differential equation is $2ydy = adx$; and this belongs to every particular equation which can be formed from the primitive, by giving all possible values to b. The constant a may also be made to disappear by putting the equation under this form,

$$\frac{y^2}{x} = a + \frac{b}{x};$$

for this by differentiation gives

$$\frac{2xydy - y^2dx}{x^2} = \frac{-bdx}{x^2},$$

$$\text{and } 2xydy - (y^2 - b)\,dx = 0;\ \text{or } \frac{dy}{dx} = \frac{y^2 - b}{2xy}.$$

This equation expresses a relation which subsists between the quantities x, y, $\frac{dy}{dx}$, independently of any particular value of the constant a.

The very same equation will be obtained by eliminating, by the ordinary process (ALGEBRA, sect. 7), a from the two equations

$$y^2 = ax + b,\ 2ydy = adx.$$

If the constant quantity which is eliminated is not of the first degree in the proposed equation, the result will contain powers of the co-efficient $\frac{dy}{dx}$ higher than the first. For example, let the equation be

$$y^2 - 2ay + x^2 = a^2;$$

then, by differentiating,

$$ydy - ady + xdx = 0,$$

hence $a = \frac{ydy + xdx}{dy}$.

This value of a being substituted in the proposed equation, we obtain, after due reduction,

$$(x^2 - 2y^2)\frac{dy^2}{dx^2} - 4xy\frac{dy}{dx} - x^2 = 0;$$

an equation that expresses a relation between x, y, $\frac{dy}{dx}$, which is independent of any particular value of a.

By resolving the equation in respect of a, we find

$$a = -y \pm \sqrt{2y^2 + x^2};$$

and hence, the constant a forming a term by itself, it disappears by differentiation, and we have

$$dy \pm \frac{2ydy + xdx}{\sqrt{2y^2 + x^2}} = 0,$$

an equation which, being freed from the radical sign, will be identical with the former.

54. Any number of constants whatever may be made to disappear by repeating the process of differentiation as often as there are quantities to be eliminated; for example, let the equation be $y^2 = m\,(a^2 - x^2)$; by a first differentiation $y\,\frac{dy}{dx} = -mx$; taking the differentials a se-

cond time, we get $y\frac{d^2y}{dx^2}+\frac{dy^2}{dx^2}=-m$. This value of $-m$ being substituted in the former equation, it becomes

$$y\frac{dy}{dx}-x\frac{dy^2}{dx^2}-xy\frac{d^2y}{dx^2}=0,$$

a result which is independent of both a and m.

Of Vanishing Fractions.

55. When the numerator and denominator of a fraction are such functions that, by giving a particular value to their variable, they both become $=0$ at the same time, the fraction is then called a *vanishing* fraction. The fraction $\frac{x^2-a^2}{x-a}$ is of this kind; for when $x=a$, the numerator and denominator both vanish, and the fraction takes the form $\frac{0}{0}$, from which we can draw no conclusion as to its true value, although it be evident that the fraction has then a determinate value; for

$$\frac{x^2-a^2}{x-a}=\frac{(x+a)(x-a)}{x-a}=x+a;$$

and when $x=a$, its true value is as $a+a=2a$.

It appears that the above fraction has taken the peculiar form $\frac{0}{0}$ when $x=a$, from the circumstance of its having the factor $x-a$ in the numerator and denominator. The same is true of this other fraction,

$$\frac{x^3-x^2a-xa^2+a^3}{ax-a^2},$$

which takes form $\frac{0}{0}$ when $x=a$. The numerator and denominator have a common divisor, $x-a$; when freed from this, it becomes $\frac{x^2-a^2}{a}$; when $x=a$, this fraction becomes $\frac{0}{a}$, which is truly $=0$. Again, this fraction $\frac{ax-a^2}{x^2-2ax+a^2}$, which has the same property when $x=a$, by reason of the common factor $x-a$, when freed from the factor is $\frac{a}{x-a}$. Thus when $x=a$ becomes $\frac{a}{0}$, that is, the value is infinite. In these cases the common factor is obvious; but it is not so always. Take this as an example, $\frac{1-\sin x+\cos x}{\sin x+\cos x-1}$; when x is a quadrant, or $=\frac{1}{2}\pi$, this fraction becomes $\frac{0}{0}$. For its true value in this case, see ex. 4 of art. 57.

56. When the terms of the fraction are algebraic functions, their greatest common measure may be found by an elementary operation in ALGEBRA (art. 20), and the fraction disengaged from it by division. A more simple and general solution may, however, be obtained from the differential calculus.

Let $\frac{P}{Q}$ denote a fraction, the terms of which are functions of x that vanish when $x=a$, some given quantity. Suppose now that x becomes $x+h$, then, by Taylor's theorem, the fraction will become

$$\frac{P+\frac{dP}{dx}h+\frac{d^2P}{dx^2}\frac{h^2}{1.2}+\frac{d^3P}{dx^3}\frac{h^3}{1.2.3}+,\&c.}{Q+\frac{dQ}{dx}h+\frac{d^2Q}{dx^2}\frac{h^2}{1.2}+\frac{d^3Q}{dx^3}\frac{h^3}{1.2.3}+,\&c.}.$$

By hypothesis, when $x=a$, then P and Q both vanish; therefore, leaving them out of the expression, and putting P', P'', P''', &c. to denote the differential co-efficients of P in the numerator, and Q', Q'', Q''', &c. those of Q in the denominator, and dividing the terms by h, the fraction will be expressed by

$$\frac{P'+\frac{1}{2}P''h+\frac{1}{6}P'''h^2+,\&c.}{Q'+\frac{1}{2}Qh+\frac{1}{6}Q'''h^2+,\&c.}.$$

When $h=0$, this expression becomes $\frac{P'}{Q'}$; and when a is put in this fraction instead of x, the result will be the true value of $\frac{P}{Q}$; for it is manifestly the same thing to suppose, first, that x becomes $x+h$, and then that $x=a$ and $h=0$, as to suppose at once that $x=a$.

If it happen that one of the two quantities, P', Q', becomes $=0$ when a is substituted instead of x, then the fraction $\frac{P}{Q}$ will be $=0$, or infinite, according as the vanishing quantity is the numerator or denominator; if both become $=0$ at once, then, leaving them out, the expression becomes, by reduction,

$$\frac{P''+\frac{1}{3}P'''h+,\&c.}{Q''+\frac{1}{3}Q'''h+,\&c.};$$

and making $h=0$, it become $\frac{P''}{Q''}$, which, putting a instead of x, will be the value of the fraction $\frac{P}{Q}$, and so on.

57. Hence we have this rule: To find the fraction $\frac{P}{Q}$ in the particular case of $x=a$, supposing that P and Q are both reduced to 0 by this supposition. Divide the differential co-efficient of the numerator by that of the denominator; let the result be $\frac{P'}{Q'}$, in which make $x=a$; then, if this expression does not become $\frac{0}{0}$, it is the value sought; but if it takes the form $\frac{0}{0}$, treat the fraction $\frac{P'}{Q'}$ in all respects like the original fraction, and deduce from it a new fraction $\frac{P''}{Q''}$, and proceed in this way until an expression be found which does not become $\frac{0}{0}$ when a is put for x; and the first expression that is found having this property is the value sought.

Ex. 1. The sum of the geometrical series

$$1+x+x^2+x^3\ldots+x^{n-1} \text{ to } n \text{ terms}$$

is $\frac{x^n-1}{x-1}$. Find its value when $x=1$.

In this case, $P=x^n-1$, $Q=x-1$; hence we deduce $\frac{dP}{dx}=nx^{n-1}=P'$; $\frac{dQ}{dx}=1=Q$, $\frac{P'}{Q'}=nx^{n-1}$;

when $x=1$, the fraction $\frac{P'}{Q'}=n$, the value of the sum of the series, as is manifest.

Ex. 2. Let the fraction be $\frac{ax^2+ac^2-2acx}{bx^2-2bcx+bc^2}=\frac{P}{Q}$, which becomes $\frac{0}{0}$ when $x=c$, to find its value. In this case $\frac{dP}{dx}=2ax-2ac=P'$; $\frac{dQ}{dx}=2bx-2bc=Q'$;

$$\frac{P'}{Q'} = \frac{2ax - 2ac}{2bx - 2bc} = \frac{ax - ac}{bx - bc}.$$

Making $x = c$, this fraction becomes $\frac{0}{0}$, therefore, proceeding as before,

$$\frac{d^2P}{dx^2} = 2a = P'', \ \frac{d^2Q}{dx^2} = 2b = Q'', \ \frac{P''}{Q''} = \frac{a}{b};$$

hence it appears that when $x = c$, the value of the fraction is $\frac{a}{b}$.

Ex. 3. The fraction $\frac{a^x - b^x}{x}$ becomes $\frac{0}{0}$ when $x = 0$. Find its value then. In this case,

$$\frac{dP}{dx} = \text{l.}\ (a)\ a^x - \text{l.}\ (b)\ b^x = P'; \ \frac{dQ}{dx} = 1 = Q'.$$

When $x = 0$, $\frac{P'}{Q'}$ becomes $\text{l.}\,(a) - \text{l.}\,(b) = \text{l.}\,\frac{a}{b}$, the value required.

Ex. 4. Let the fraction be $\frac{1 - \sin x + \cos x}{\sin x + \cos x - 1}$, which becomes $\frac{0}{0}$ when $x = \frac{1}{2}\pi$. Here

$$\frac{dP}{dx} = -\cos x - \sin x = P'; \ \frac{dQ}{dx} = \cos x - \sin x = Q';$$

$$\frac{P'}{Q'} = \frac{-\cos x - \sin x}{\cos x - \sin x}.$$

When $x = \frac{1}{2}\pi$, a quadrant, then $\cos x = 0$, and $\sin x = 1$; the value of the proposed fraction is therefore $\frac{-1}{-1} = 1$.

Ex. 5. Let the fraction be $\frac{a^{a-n} - x^{x-n}}{a - x}$; to find its value when $x = a$. In this case $P = a^{a-n} - x^{x-n}$, $Q = a - x$.

$$P' = \frac{dP}{dx} = -x^{x-n}\left\{\text{l.}\,x + \frac{x-n}{x}\right\};$$

$$Q' = \frac{dQ}{dx} = -1,$$

$$\frac{P'}{Q'} = x^{x-n}\left\{\text{l.}\,x + \frac{x-n}{x}\right\}:$$

making $x = a$, we have $a^{a-n}\left\{\text{l.}\,a + \frac{a-n}{a}\right\}$ for the value required.

58. The rule of last article will not apply when Taylor's theorem fails to give the developments of the functions P, Q, in the case when $x = a$. When this happens, we may substitute $a + h$ instead of x in the fraction $\frac{P}{Q}$, and expand the numerator and denominator into ascending series, which proceed by the powers of h; we shall then have

$$\frac{Ah^{\alpha} + Bh^{\beta} +, \&c.}{A'h^{\alpha'} + B'h^{\beta'} +, \&c.}$$

instead of the proposed fraction. If in this result we suppose $h = 0$, we shall have the value of the fraction $\frac{P}{Q}$ when $x = a$. Now there are here three cases; viz. $\alpha > \alpha'$, $\alpha = \alpha'$, and $\alpha < \alpha'$. In the first case, we may write the expression thus:

$$\frac{Ah^{\alpha - \alpha'} + Bh^{\beta - \alpha} +, \&c.}{A' + B'h^{\beta - \alpha'} +, \&c.};$$

Under this form, it is manifest that as long as α is greater than α', the supposition of $h = 0$ will make the fraction equal to nothing, and that it will become $\frac{A}{A'}$ when $\alpha = \alpha'$; but when $\alpha < \alpha'$, we write the expression thus:

$$\frac{A + Bh^{\beta - \alpha} +, \&c.}{A'h^{\alpha' - \alpha} + B'h^{\beta' - \alpha} +, \&c.};$$

and by the supposition of $h = 0$, this result becomes infinite. In all cases the true value depends on the first term alone of each series.

59. The following rule extends to all fractions which can occur under the indeterminate form $\frac{0}{0}$.

Take the first term of each of the series which express the development of the numerator and denominator when x = a + h; *reduce the resulting fraction to its most simple form, and then make* h = 0.

The fraction $\frac{(x^2 - a^2)^{\frac{5}{2}}}{(x - a)^{\frac{5}{2}}}$, whose value cannot be found by differentiation, when $x = a$ becomes by this method

$$\frac{(2ah + h^2)^{\frac{5}{2}}}{h^{\frac{5}{2}}} = (2a + h)^{\frac{5}{2}},$$

when x is changed into $x + h$; making now $h = 0$, we have its true value $(2a)^{\frac{5}{2}}$.

This last rule will sometimes be preferable to the former, by differentiation, even when that process is applicable. For example, four successive differentiations must be performed on the numerator and denominator of this fraction,

$$\frac{x^3 - 4ax^2 + 7a^2x - 2a^3 - 2a^2\sqrt{2ax - a^2}}{x^2 - 2ax - a^2 + 2a\sqrt{2ax - x^2}},$$

in order to find its true value when $x = a$; by writing $a + h$ instead of x, it becomes

$$\frac{2a^3 + 2a^2h - ah^2 + h^3 - 2a^2\sqrt{a^2 + 2ah}}{-2a^2 + h^2 + 2a\sqrt{a^2 - h^2}}$$

and reducing the radical quantities into series, we have

$$\sqrt{a^2 + 2ah} = a + h - \frac{h^2}{2a} + \frac{h^3}{2a^2} - \frac{5h^4}{8a^3} +, \&c.$$

$$\sqrt{a^2 - h^2} = a - \frac{h^2}{2a} - \frac{h^4}{8a^3} -, \&c.$$

By substituting these series in the fraction, and putting $h = 0$, we obtain $-5a$ for the value sought.

Of the greatest and least Values of a Function.

60. In supposing that a function changes its value, we may assume that the variable increases continually from 0 to infinity, either positively or negatively. To get distinct notions, it may be convenient to suppose that the variable increases or decreases by successive equal differences. The function however may not increase or decrease continually along with its variable. It may first increase to a certain magnitude, and afterwards decrease; or it may decrease and afterwards increase; or it may alternately increase and decrease several times. We may represent the variable x by the abscissa of a curve, and the function y by the corresponding ordinate. The curve, from

Direct Method.

its nature, may recede continually from its axis, like the parabola and hyperbola; or it may first recede from and afterwards approach to the axis, like the circle and ellipse; or it may be sinuous, alternately approaching and receding.

When a variable function, by a continual change in its magnitude, first increases and afterwards decreases, there will be one value of the function which will be greater than those which immediately preceded it, and also greater than those which immediately follow it. In this state the value of the function is the greatest possible, at least within certain limits on each side of that extreme value; and then it is said to be a *maximum*. On the other hand, if a function, by a continual change in its value, first decreases, until it be reduced to a certain magnitude, and afterwards increases, it is said to be a *minimum*, when it is just changing from the state of a decreasing to that of an increasing quantity.

A variable function may have several values, each of which will be a *maximum* or *minimum*, according to the definition. *The essential character of a maximum consists in its being greater than the values which preceded and which follow it; and that of a minimum in being less than the preceding and following values.* So that as many changes as there may be from increase to decrease, or the contrary, so many *maxima* and *minima* there will be.

61. Before proceeding farther, it will be convenient to establish this principle. In a series of the form

$$ph + qh^2 + rh^3 + sh^4 +, \&c.$$

in which h is indeterminate, and independent of p, q, r, &c. such a value may be given to h, that any term shall exceed the amount of all that follow it. For, putting the series under this form,

$$h\,(p + qh + rh^2 + sh^3 +, \&c.);$$

by supposing h to decrease, $qh + rh^2 + sh^3 +$, &c. may become less than any assignable quantity, and therefore less than p; consequently, $qh^2 + rh^3 + sh^4 +$, &c. may be less than ph, in any ratio of inequality. In the same way it will appear that $rh + sh^2 +$, &c. may be less than q, and $rh^3 + sh^4 +$, &c. less than qh^2, and so on. Hence it follows, that in the series $ph + qh^2 + rh^3 + sh^4 +$, &c. h may have such a value that the amount of all the terms beginning with any assigned term shall have the sign of that term, $+$ if it be $+$, and $-$ if it be $-$.

62. Let y denote any function which may become a *maximum* or *minimum* when its variable has attained some particular value; then, if $x - h$ and $x + h$ be substituted successively in the function instead of x, the two results must be both less than the maximum value, and both greater than the minimum value. Denoting now the value of the function which corresponds to $x - h$ by ${}_1y$, and the value which corresponds to $x + h$ by y_1, we have, by Taylor's theorem,

$${}_1y = y - \frac{dy}{dx}h + \frac{d^2y}{dx^2}\frac{h^2}{1.2} - \frac{d^3x}{dx^3}\frac{h^3}{1.2.3} +, \&c.$$

$$y_1 = y + \frac{dy}{dx}h + \frac{d^2y}{dx^2}\frac{h^2}{1.2} + \frac{d^3y}{dx^3}\frac{h^3}{1.2.3} +, \&c.$$

Now, it is impossible that ${}_1y$ and y_1 can at the same time be both less or both greater than y, if the co-efficient $\frac{dy}{dx}$ be not $= 0$; for if it have some value different from *zero*, then such a value may be given to h that $\frac{dy}{dx}h$ shall exceed in any given ratio of inequality all the terms which follow it, and one of the two series beginning with $\mp\frac{dy}{dx}h$ will be a positive quantity and the other negative; and if this were true, y would be of an intermediate magnitude between ${}_1y$ and y_1, which cannot be, when it is a *maximum* or *minimum*. Therefore, in order that y may be a *maximum* or *minimum*, we must have $\frac{dy}{dx} = 0$, and then, in the expressions

$${}_1y = y + \frac{d^2y}{dx^2}\frac{h^2}{1.2} - \frac{d^3y}{dx^3}\frac{h^3}{1.2.3} +, \&c.$$

$$y_1 = y + \frac{d^2y}{dx^2}\frac{h^2}{1.2} + \frac{d^3y}{dx^3}\frac{h^3}{1.2.3} +, \&c.$$

such a value may be given to h as shall make ${}_1y$ and y_1 both less than y in the case of a *maximum*, or both greater in that of a *minimum*.

It may, however, happen that the value of x which makes $\frac{d^2y}{dx^2} = 0$ shall also make $\frac{d^2y}{dx^2} = 0$, so that we have

$${}_1y = y - \frac{d^3y}{dx^3}\frac{h^3}{1.2.3} + \frac{d^4y}{dx^4}\frac{h^4}{1.2.3.4} -, \&c.$$

$$y_1 = y + \frac{d^3y}{dx^3}\frac{h^3}{1.2.3} + \frac{d^4y}{dx^4}\frac{h^4}{1.2.3.4} +, \&c.$$

Then the function cannot be a maximum or minimum, unless the same value of x make $\frac{d^3y}{dx^3} = 0$, and give a finite value for $\frac{d^4y}{dx^4}$

63. On the whole, we have this rule, to determine the maximum or minimum value of y, a function of x.

Make the differential co-efficient $\frac{dy}{dx} = 0$: *Find the value of* x, *and substitute it in* $\frac{d^2y}{dx^2}$; *and if the result be negative, the function is a* maximum; *but if it be positive, the function is a* minimum. *And if it be* $= 0$, *then put* $\frac{d^3y}{dx^3} = 0$, *and find* x, *and substitute it in* $\frac{d^4y}{dx^4}$, *and draw the same conclusions from the signs as before, and so on.*

The rule for determining a maximum or minimum of a function was first given correctly by Maclaurin, in his FLUXIONS, chap. ix.

64. We shall now apply the theory to the resolution of problems, of which there may be an endless variety, and many highly interesting.

Ex. 1. To determine whether the function $u = 2ax - x^2$ has a *maximum* or *minimum* value.

In this case the differential co-efficient $\frac{du}{dx} = 2\,(a - x)$, which being put $= 0$, we have $x = a$. The second differential co-efficient $\frac{d^2u}{dx^2} = -2$, a negative quantity, therefore the function has a maximum value (art. 63), viz. when $x = a$; and that value is $u = a^2$, as is indeed evident from the nature of the function.

Ex. 2. Let $u = x^2 + 3x + 2$; then $\frac{du}{dx} = 2x + 3$. This put $= 0$, gives $x = -\frac{3}{2}$. Again, $\frac{d^2u}{dx^2} = 2$, a positive quantity, therefore the function is a *minimum* when $x = -\frac{3}{2}$. In that case $u = -\frac{1}{4}$.

Ex. 3. Let $u = x^3 - 15x^2 + 56x - 60$. Here

$$\frac{du}{dx} = 3x^2 - 30x + 56,\ \frac{d^2u}{dx^2} = 6x - 30.$$

Direct Method.

The equation $\frac{du}{dx} = 3x^2 - 30x + 56 = 0$ being resolved, we find $x = \frac{15 \pm \sqrt{57}}{3}$. Making $x = \frac{15 \pm \sqrt{57}}{3}$, we find $\frac{d^2u}{dx^2} = 6x - 30 = \pm 2\sqrt{57}$. Hence it appears that the function has a *minimum*, and also a *maximum* value; the former corresponding to $x = \frac{15 + \sqrt{57}}{3}$, and the latter to $x = \frac{15 - \sqrt{57}}{3}$.

If $x = \frac{15 + \sqrt{57}}{3}$, $u = -30 - \frac{38}{9}\sqrt{57}$, a *minimum.*

If $x = \frac{15 - \sqrt{57}}{3}$, $u = -30 + \frac{38}{9}\sqrt{57}$, a *maximum.*

Ex. 4. Let $u = x^5 - 5x^4 + 5x^3 + 1$;

then $\frac{du}{dx} = 5x^4 - 20x^3 + 15x^2 = 5x^2(x^2 - 4x + 3)$;

$$\frac{d^2u}{dx^2} = 20x^3 - 60x^2 + 30x = 10x(2x^2 - 6x + 3).$$

The equation $\frac{du}{dx} = 5x^2(x^2 - 4x + 3) = 0$,

gives four values of x, viz. $x = 3, x = 1$, the other two are $= 0$.

These being substituted in $\frac{d^2u}{dx^2}$, show that the function has a *maximum* and *minimum:*

when $x = 3$, $u = -26$, a *minimum;*

$x = 1$, $u = 2$, a *maximum;*

when $x = 0$, then $\frac{d^2u}{dx^2}$ vanishes, therefore there is neither *maximum* or *minimum* in this case.

Ex. 5. To determine the *maxima* and *minima* values of the function $y = x^x$; we have found (art. 24, ex. 2), that

$$\frac{dy}{dx} = x^x(1 + \text{l}.\,x);$$

and hence $\frac{d^2y}{dx^2} = x^x \left\{ \frac{1}{x} + (1 + \text{l}.\,x)^2 \right\}$;

The function x^x cannot be $= 0$; we must therefore put $1 + \text{l}.\,x = 0$;

hence $\text{l}.\,x = -1$, and $x = e^{-1} = \frac{1}{e}$.

This value of x, substituted in the second differential coefficient, makes

$$\frac{d^2u}{dx^2} = \left(\frac{1}{e}\right)^{\frac{1}{e}} . e, \text{ a positive quantity};$$

therefore, when $x = \frac{1}{e}$, $x^x = \left(\frac{1}{e}\right)^{\frac{1}{e}}$, a *minimum.*

Ex. 6. To find the greatest space that can be enclosed by four given straight lines:

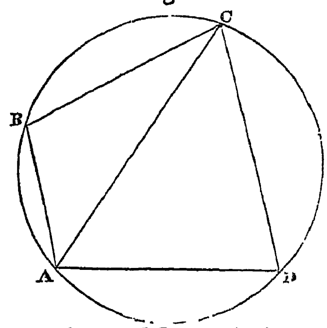
Let the given lines be AB $= a$, BC $= b$, CD $= e$, DA $= f$: Let $x =$ angle B, $v =$ angle D, $y =$ the area ABCD: Draw the diagonal AC.

By trigonometry, $a^2 + b^2 - 2ab \cos x = \text{AC}^2$,

$e^2 + f^2 - 2ef \cos v = \text{AC}^2$;

Hence, $2ab \cos x - 2ef \cos v = a^2 + b^2 - e^2 - f^2$.........(1)

Fig. 1.



And because trian. ABC $= \frac{1}{2}ab \sin x$; trian. ADC $= \frac{1}{2}ef \sin v$,

therefore, $y = \frac{1}{2}ab \sin x + \frac{1}{2}ef \sin v$.........................(2)

This last equation by differentiation gives, by the nature of a maximum,

$\frac{dy}{dx} = \frac{1}{2}ab \cos x + \frac{1}{2}ef \frac{dv}{dx} \cos v = 0$.......................(3)

By differentiating equation (1), we find

$$ab dx \sin x - ef dv \sin v = 0;$$

and hence $ef \frac{dv}{dx} = ab \frac{\sin x}{\sin v}$:

Therefore, from eq. (3), $ab \left\{ \cos x + \frac{\sin x \cos v}{\sin v} \right\} = 0$;

and hence $\sin v \cos x + \cos v \sin x = 0$;

that is (Algebra, art. 239), $\sin(x + v) = 0$, and $x + v = \pi$.

Thus it appears that the opposite angles B, D must together make two right angles; therefore the figure will be a *maximum* when it is inscribed in a circle; and since in this case

$$\cos x = -\cos v, \ \sin x = \sin v;$$

from equations (1) and (2),

$2(ab + ef) \cos x = a^2 + b^2 - e^2 - f^2$,

$2(ab + ef) \sin x = 4y$.

By squaring both sides of these equations, and adding, and observing that $\cos^2 x + \sin^2 x = 1$, we have

$4(ab + ef)^2 = (a^2 + b^2 - e^2 - f^2)^2 + 16y^2$,

and $16y^2 = 4(ab + ef)^2 - (a^2 + b^2 - e^2 - f^2)^2$.

The right-hand side of this formula admits of being resolved into these two factors, viz.

$2ab + 2ef + a^2 + b^2 - e^2 - f^2 = (a + b)^2 - (e - f)^2$,

$2ab + 2ef - a^2 - b^2 + e^2 + f^2 = (e + f)^2 - (a - b)^2$;

and these again admit of this further resolution,

$(a + b + e - f)(a + b - e + f)$,

$(e + f + a - b)(e + f - a + b)$;

If we now put $s = \frac{1}{2}(a + b + e + f)$,

we have $a + b + e - f = 2(s - f)$,

$a + b - e + f = 2(s - e)$,

$e + f + a - b = 2(s - b)$,

$e + f - a + b = 2(s - a)$.

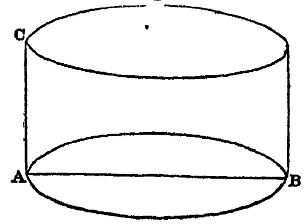
Hence $16y^2 = 16(s - a)(s - b)(s - e)(s - f)$;

and $y = \sqrt{(s - a)(s - b)(s - e)(s - f)}$.

We have now found by the calculus an elegant geometrical theorem.

Ex. 7. To determine the dimensions of a cylindric measure, open at top, which shall contain a given quantity of grain, liquor, &c. under the least internal superficies.

Fig. 2.



Direct Method.

Let $x =$ AB be the diameter of the base, $v =$ AC its depth, π the number 3·1416 (viz. half the circumference of a circle whose rad. $= 1$), and c the content of the cylinder. By GEOMETRY, the area of the base $= \frac{\pi x^2}{4}$, and its circumference $= \pi x$, and the internal curved surface of the cylinder $= v\pi x$. Now, the content of the cylinder $c = \frac{\pi x^2 v}{4}$; and therefore $v = \frac{4c}{\pi x^2}$; therefore the internal curved surface $= \frac{4c}{x}$; and putting y for the whole inside surface of the measure,

$$y = \frac{\pi x^2}{4} + \frac{4c}{x},$$

$$\text{therefore, } \frac{dy}{dx} = \frac{\pi x}{2} - \frac{4c}{x^2} = 0;$$

$$\frac{d^2y}{dx^2} = \frac{\pi}{2} + \frac{8c}{x^3}.$$

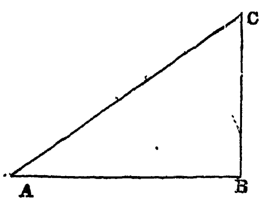
The first of these equations gives

$$\pi x^3 = 8c = 2\pi x^2 v, \text{ and } x = 2v;$$

hence the diameter of the base must be twice the depth: The second differential co-efficient being a positive quantity, shows the surface to be a *minimum*.

Ex. 8. A candle stands on a horizontal table, directly over a point at a given distance from a small object on the table; what ought to be the height of the flame when the object is illuminated the most possible.

Fig. 3.



Let A be the object on the table, B the point under the candle, and C the flame, considered as condensed at a point. The intensity of the illumination on the object A depends on its distance from C, and on the angle which the rays make with the surface (supposed to be horizontal). By the principles of optics, the intensity at different distances, the angle of obliquity being the same, will be inversely as the square of the distance; and with different degrees of obliquity, the distance being the same, as the sine of the angle which the rays make with the surface. Therefore the intensity, as depending on both obliquity and distance, will be expressed by

$$\frac{1}{AC^2} \sin CAB = \frac{BC}{AC^3}.$$

Put $a =$ AB, $x = \sin$ CAB, and let y denote the illuminating power on the surface at A; then

$$y = \frac{BC}{AC} \times \frac{AB^2}{AC^2} \times \frac{1}{AB^2} = \frac{\sin x \cos^2 x}{a^2},$$

$$\frac{dy}{dx} = \left\{ \cos^3 x - 2 \sin^2 x \cos x \right\} \frac{1}{a^2} = 0;$$

hence, $2 \sin^2 x \cos x = \cos^3 x$,

$$\text{and } \frac{\sin^2 x}{\cos^2 x} = \frac{1 - \cos 2x}{1 + \cos 2x} = \tfrac{1}{2}, \text{ and } \cos 2x = \tfrac{1}{3}.$$

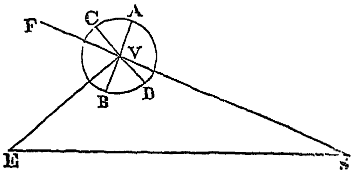
By the trigonometrical tables, $2x = 70° 32'$, and $x = 35° 16'$; this gives BC $=$ AB $\times$ .71 nearly: so that the height of the flame must be about $\frac{7}{10}$ of the distance AB.

Ex. 9. To find the position of the planet Venus in respect of the earth and sun when her light is the greatest.

The planet does not appear brightest when her disc is perfectly round; she is then too remote to produce that effect; and besides, she is seen in the direction of the sun. In her inferior conjunctions her crescent is too narrow, almost the whole illuminated part being turned towards the sun. It is therefore in some intermediate position, which is to be determined, that she is brightest.

Let S be the sun, E the earth, and ACBD Venus, ADB its illuminated hemisphere which is turned towards the sun, and CBD its hemisphere towards the earth: produce S V to F.

Fig. 4.



The portion of the illuminated surface turned towards the earth is contained between two planes DV, BV, perpendicular to the plane EVS; and this surface will manifestly be projected into a crescent, the breadth of which is the versed sine of the angle BVD, which is equal to EVF, because if BVE be added to both, each is a right angle. Now the area of the crescent is always as its breadth; therefore, the whole disk being taken as an unit, the illuminated part of it will be expressed by the versed sine of the angle EVF, or by $1 + \cos$ EVS.

Again, the brightness of the planet at different distances is inversely as the square of the distance; therefore the brightness depending on its position in respect of the sun and its distance from the earth jointly, will be proportional to $\frac{1 + \cos EVS}{EV^2}$.

Let $a =$ ES the distance of the earth from the sun,
$b =$ VS the distance of Venus from the sun,
$x =$ VE the distance of Venus from the earth;

$$\text{Then, } \cos EVS = \frac{x^2 + b^2 - a^2}{2bx},$$

$$\text{and } 1 + \cos EVS = \frac{x^2 + 2bx + b^2 - a^2}{2bx}$$

$$= \frac{(x + b + a)(x + b - a)}{2bx};$$

therefore, putting y to denote the brightness of the planet,

$$y = \frac{(x + b + a)(x + b - a)}{2bx^3} \text{ a } maximum;$$

and this, by differentiation, gives

$$\frac{dy}{dx} = \frac{(x + b + a)(x + b - a)}{2bx^3} \left\{ \frac{1}{x + b + a} + \frac{1}{x + b - a} - \frac{3}{x} \right\} = 0;$$

$$\text{and hence, } 3(a^2 - b^2) - 4bx - x^2 = 0;$$

$$x^2 + 4bx = 3(a^2 - b^2),$$

$$x = \pm\sqrt{3a^2 + b^2} - 2b.$$

The negative value of x is not applicable, and we have

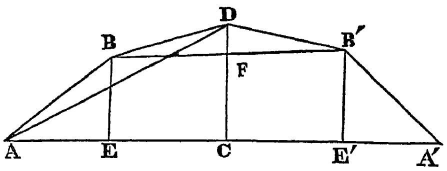
$$x = \sqrt{3a^2 + b^2} - 2b.$$

In numbers, $a = 10000$, $b = 7233$, therefore $x = 4304$, the angles E $= 39° 43' 30''$, V $= 117° 55' 20''$, S $= 22° 21' 10''$.

Ex. 10. Let ABDB'A' be a kirb roof supported by

four rafters AB, BD, DB′, B′A′, two and two of which are equal, viz. AB = A′B′, and BD = B′D, and all perfectly free to turn about the points A, B, D, B′, A′, as joints. Suppose also that AA′ the span, and DC the height of the roof, are given, and that AB has to BD a given ratio. Determine the position of the rafters when by their weight they form an equilibrium.

Fig. 5.



Suppose the roof to be inverted so as to form a polygon hanging suspended from the points A, A′; by a known principle in statics, when it forms an equilibrium, the centre of gravity of the mass of matter in the polygon will be the lowest possible. If now the polygon were reversed and placed in its position as a roof, without changing the angles at the joints, the equilibrium would not be disturbed, and in this position the centre of gravity would be the highest possible.

Draw a line from B to B′, which will be parallel to AA′; and draw the perpendiculars BE, B′E′. Put the angle BAC = B′A′C = x, DBF = DB′F = v; let the given ratio of AB to BD be that of a given number m to a given number n; these numbers may represent the length, also the weight, of the rafters, which may be supposed placed in their centres of gravity, or middle of the beams.

By trigonometry, BE = $m \sin x$, DF = $n \sin v$, therefore DC = $m \sin x + n \sin v$; and, by statics, the height of the centre of gravity of AB, also of A′B′, above AA will be $\frac{1}{2}$ BE = $\frac{1}{2} m \sin x$, and the height of the centre of gravity of BD, also of B′D, will be $\frac{1}{2}$ (BE + DC) = $m \sin x + \frac{1}{2} n \sin v$; and since the distance of the common centre of gravity of all the beams from AA′ will be found by multiplying the distance of each centre by the mass, supposed placed at that centre, and adding the results into one sum, and dividing by the sum of all the masses; the height of the centre of gravity of the whole system of beams above AA′ will be

$$\frac{m^2 \sin x + n\,(2\,m \sin x + n \sin v)}{2\,(m + n)}.$$

Let this height be denoted by y; then, rejecting the constant denominator $2\,(m + n)$,

$y = (m^2 + 2\,mn) \sin x + n^2 \sin v$, a maximum; and since AC, half the span of the roof, is a given quantity, we have

$$m \cos x + n \cos v = \text{AC, } a \textit{ constant.}$$

From the first equation,

$$\frac{dy}{dx} = (m^2 + 2\,mn) \cos x + n^2 \cos v \frac{dv}{dx} = 0;$$

and from the second,

$$m \sin x + n \sin v \frac{dv}{dx} = 0; \text{ hence } \frac{dv}{dx} = -\frac{m \sin x}{n \sin v}.$$

This value of $\frac{dv}{dx}$ being substituted in the value of $\frac{dy}{dx}$, we obtain

$$(m^2 + 2\,mn) \cos x - \frac{mn \cos v \sin x}{\sin v} = 0;$$

and from this again,

$$\frac{\tan x}{\tan v} = \frac{m}{n} + 2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1.)$$

This formula expresses a property of all roofs made of four beams, which are equal two and two, when by their position they form an equilibrium.

Join AD, and put γ = angle DAC which is known, because $\tan \gamma = \frac{\text{DC}}{\text{AC}}$. The angle BAD $= x - \gamma$, and BDA $= \gamma - v$. Now, in the triangle ABD, sin A : sin D = DB : BA, that is, $\sin (x - \gamma) : \sin (\gamma - v) = n : m$; therefore,

$$\frac{\sin (x - \gamma)}{\sin (\gamma - v)} = \frac{n}{m} \ldots\ldots\ldots\ldots(2.)$$

These equations (1), (2), determine the angles x, v, when the ratio of AB to BD is given; from their form, the angles may be easily found by trials in the trigonometrical tables. The elimination of one of the angles would produce an equation of the fourth degree; for this reason, the method of trials is the best way of proceeding. When the angles x and v are known, every thing else may be readily found.

If we suppose the beams AB, BD, to be of equal length, then $m = n$, and our two equations become

$$\frac{\tan x}{\tan v} = 3, \quad \sin (x - \gamma) = \sin (\gamma - v).$$

In this case, $x + v = 2\gamma$; then, from the equation

$$\frac{\tan x}{\tan v} = \frac{\sin x \cos v}{\cos x \sin v} = 3,$$

we get $$\frac{\sin x \cos v - \cos x \sin v}{\sin x \cos v + \cos x \sin v} = \frac{\sin (x - v)}{\sin (x + v)} = \tfrac{1}{2};$$

and hence $\sin (x - v) = \frac{1}{2} \sin (x + v) = \frac{1}{2} \sin 2\gamma$; and putting for v its value $2\gamma - x$,

$$\sin 2\,(x - \gamma) = \tfrac{1}{2} \sin 2\gamma.$$

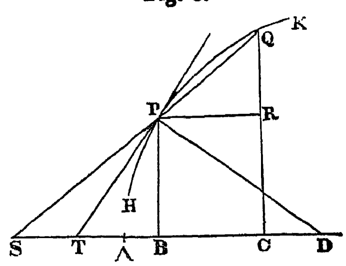
This determines the angle x, and $v = 2\gamma - x$.

The theory of equilibriums opens a wide field for the application of the calculus, as must be evident from the preceding solution; but our limits will not permit us to enter on it farther.

Determination of Tangents to Curves.

65. Let HPK be any curve referred to an axis AC; and let AB = x and PB = y be the co-ordinates of any point P in the curve; the point A being the origin of the abscisses. Let PT, a tangent to the curve at P, meet the axis in T; and let SPQ, any straight line drawn through P, meet the curve in Q and the axis in S. Draw QC perpendicular to the axis, and PR perpendicular to QC; and let PR = BC = h, and QC = y', the ordinate corresponding to the absciss $x + h$.

Fig. 6.



By similar triangles, QR : RP = PB : BS, that is,

$$y' - y : h = y : \text{BS}.$$

Now, by Taylor's theorem (art. 31),

$$y' - y = \frac{dy}{dx} h + \frac{d^2y}{d^2x} h^2 + \text{\&c.}$$

hence, dividing the first antecedent and consequent by h,

$$\frac{dy}{dx}+\frac{d^2y}{dx^2}h+\text{\&c.}:1=y:\text{BS}.$$

This proposition holds true whatever be the magnitude of h, the increment of x. But now let us suppose h to decrease continually; the point Q will approach to P, and the line QPS approaching to coincidence with PT, the point S will approach to T; and when h vanishes, Q will be at P, and S at T, and BS will have become BT; our proportion will now be

$$\frac{dy}{dx}:1=y:\text{BT}.$$

The line BT, between the ordinate PB and tangent PT, is called the *subtangent;* from this proportion it appears, that x and y being co-ordinates at any point in the curve,

$$\text{BT, the subtangent,}=y\div\frac{dy}{dx}=y\frac{dx}{dy};\ldots\ldots\ldots\ldots(1)$$

that is, the subtangent is equal to the ordinate divided by its differential co-efficient; or it is a third proportional to the differential of the ordinate, the differential of the abscissa and the ordinate. The subtangent being known, the position of the tangent is determined.

Let PD, a perpendicular to the tangent at P, and consequently to the curve, meet the axis in D; the line PD is called a *normal* to the curve; and BD, the segment of the axis between the ordinate and normal, is called the *subnormal.*

The triangles TBP, PBD are similar, therefore

$$\text{TB}:\text{BP}=\text{BP}:\text{BD, or } dx:dy=y:\text{BD},$$

$$\text{hence the } \textit{subnormal}\ \text{BD}=y\frac{dy}{dx}\ldots\ldots\ldots(2).$$

Because the tangent of the angle $\text{PTB}=\frac{\text{PB}}{\text{TB}}$, and the tangent of the angle $\text{PDB}=\frac{\text{PB}}{\text{BD}}$; therefore,

$$\tan \textit{angle}\ \text{T}=\frac{dy}{dx}, \text{ and } \tan \text{D}=\frac{dx}{dy}\ldots\ldots\ldots(3).$$

In the right-angled triangles TBP, PBD, we have $\text{PT}^2=\text{PB}^2+\text{BT}^2$, and $\text{PD}^2=\text{PB}^2+\text{BD}^2$; therefore,

$$\textit{tangent}\ \text{PT}=y\sqrt{1+\frac{dx^2}{dy^2}}\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

$$\textit{normal}\ \text{PD}=y\sqrt{1+\frac{dy^2}{dx^2}}\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

66. We shall now apply these general formulæ to some particular curves.

Ex. 1. Let the curve be the parabola, and supposing AC to be the axis, and A its vertex: by the nature of the curve, putting a for the parameter, $y^2=ax$,

$$\text{hence } 2ydy=adx;\ \frac{dx}{dy}=\frac{2y}{a},$$

$$\text{subtan. BT}=\frac{dx}{dy}y=\frac{2y^2}{a}=\frac{2ax}{a}=2x;$$

that is, the subtangent is double the absciss AB.

Again, for the subnormal, we have

$$\text{subnor. BD}=\frac{dy}{dx}y=\frac{adx}{2dx}=\frac{a}{2}.$$

Thus it appears that the subnormal is constant, and equal to half the parameter.

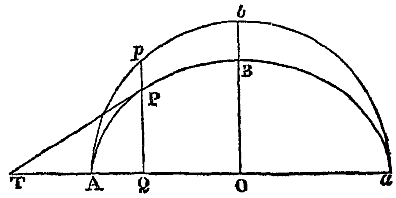
Ex. 2. Let the curve be an ellipse, of which OA half the greater axis $=a$, OB half the lesser axis $=b$; and supposing the origin of the co-ordinates to be at O the centre, let $\text{OQ}=x$, $\text{PQ}=y$. By the nature of the curve,

$$a^2:b^2=(a+x)(a-x):y^2 \text{ (Conics)};$$

$$\text{hence } y^2=\frac{b^2}{a^2}(a^2-x^2), \text{ and } ydy=-\frac{b^2xdx}{a^2};$$

$$\text{and subtan. QT}=\frac{dx}{dy}y=-\frac{a^2y^2}{b^2x}=-\frac{a^2-x^2}{x}=-\left(\frac{a^2}{x}-x\right).$$

Fig. 7.



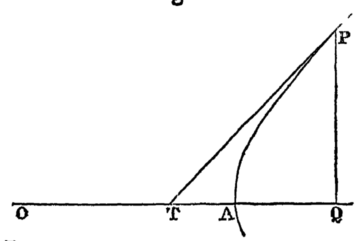
The general formula for the subtangent was found on the hypothesis that it was on the same side of the ordinate as the absciss; in this case they are supposed to be on opposite sides, and hence its value has the negative sign; leaving the direction of the subtangent in respect of the absciss out of consideration, we have

$$\text{QT}=\frac{a^2}{x}-x, \text{ and OT}=\frac{a^2}{x},$$

hence it appears that $\text{OQ}:\text{OA}=\text{OA}:\text{OT}$.

When the axes are equal, the ellipse becomes a circle, but the subtangent is independent of the ratio of the axes.

Fig. 8.



Ex. 3. Let the curve be the hyperbola, of which $a=\text{OA}$ the semitransverse axis, and $b=$ the semiconjugate; then, putting $\text{OQ}=x$, and $\text{PQ}=y$, we have (by Conics),

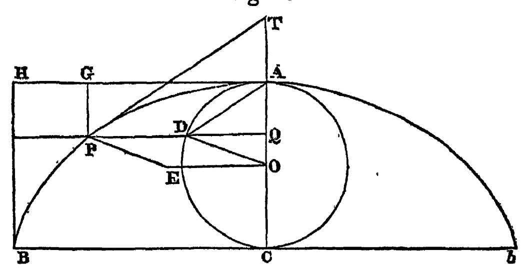
$$y^2=\frac{b^2}{a^2}(x^2-a^2),\quad ydy=\frac{b^2}{a^2}xdx;$$

$$\text{subtan. QT}=\frac{dx}{dy}y=\frac{a^2y^2}{b^2x}=\frac{x^2-a^2}{x}=x-\frac{a^2}{x};$$

$$\text{hence OT}=\text{OQ}-\text{QT}=\frac{a^2}{x}.$$

This shows that the tangent always passes between the centre and the vertex when x has a finite value; but when x becomes infinite, then $\text{OT}=0$, and the tangent becomes an asymptote to the hyperbola.

Fig. 9.



Ex. 4. We shall next draw a tangent to the cycloid; but first the nature of the curve must be expressed analytically. Conceive a circle to roll along a straight line, moving always in the same plane, just as the wheel of a carriage rolls along a straight road. By this motion any given point in the circumference of the circle will describe

a continuous curve in that plane, which will meet the line along which it rolls at intervals equal to its circumference.

Let bB be the line along which a circle CDA rolls, beginning its motion from a point of contact b, and completing a revolution when it has come to B. The point of the circumference which was in contact with the line at b will then have generated the curve line bAB. This is the *cycloid*, and the line bB its *base*.

Let ADC be a fixed circle in the position of the *generating* circle when it has completed half a revolution, O its centre, and AC its diameter, called the axis of the cycloid. Let AD be any arc of this circle. Draw the radius OD. When the generating circle, by rolling along CB from the position C, has passed over a distance equal to the arc AD, the centre O will have generated a straight line OE parallel to CB, and equal to the same arc AD; moreover, the moveable radius, which was coincident with OA, will, by the rotation of the circle, have come into a position EP, parallel to OD, because the angular motion of the radius about the moving point E will always be proportional to the arc of the circle that has been applied to the base, that is, by hypothesis, to the arc AD; and since the lines OD, EP are equal and parallel, a straight line drawn from P through D, meeting AC in Q, will be parallel to EO, and therefore perpendicular to AC; and since PD = OE = arc AD, it follows that PQ, any ordinate to the axis AC, is equal to the sum of the arc AD and its sine DQ. This is the distinguishing property of a cycloid. To express it by equations, let the radius of the generating circle be a, and the angle AOD $= v$, then PD = arc AD $= av$, and DQ $= a \sin v$, so that, putting AQ $= x$, and PQ $= y$, we have for the equations of the curve

$$x = a\,(1 - \cos v), \quad y = a\,(v + \sin v);$$

and from these every property of the curve may be investigated.

To determine the tangent: by differentiation,

$$dx = adv \sin v, \quad dy = adv\,(1 + \cos v), \quad \frac{dx}{dy} = \frac{\sin v}{1 + \cos v},$$

$$\text{subtan QT} = y\frac{dx}{dy} = \frac{(v + \sin v)\sin v}{1 + \cos v} = \frac{\text{PQ}\,.\,\text{QD}}{\text{CQ}};$$

hence CQ : DQ = PQ : QT.

But by the nature of the circle CQ : DQ = DQ : QA; therefore PQ : QT = DQ : QA; hence the triangles PQT, DQA are similar, and the tangent PT is parallel to the chord DA.

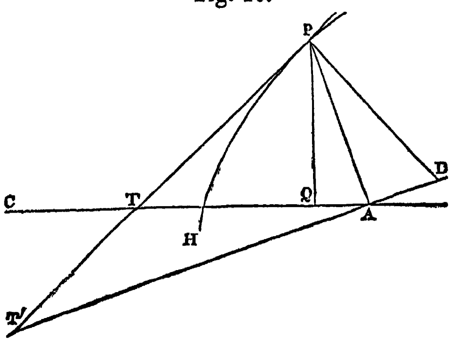
Ex. 5. In the logarithmic curve of which the equation is $y = a^x$, we have $dy = a^x \,.\, \text{l.}\, a \,.\, dx = y\,\text{l.}\, a \,.\, dx$; therefore

$$\frac{dx}{dy}y = \frac{1}{\text{l.}\, a} = \text{subtangent.}$$

Hence it appears that the subtangent is a line of a constant given length.

67. To find a formula for the subtangent and normal of curves whose nature is expressed by a polar equation.

Fig. 10.



Let HPK be such a curve, generated by the revolution of a variable radius AP about a given point A in AC, a line given in position. Through A draw AT' perpendicular to AP; let a tangent to the curve at P meet this line in T' and the axis in T; draw PQ perpendicular to the axis AC, and draw the normal PD, meeting T'A in D. Then AT' is the subtangent and AD the subnormal. Let AQ $= x$, PQ $= y$, the revolving radius AP $= r$, the variable angle PAC $= v$, and the angle PTA $= t$. The lines x, y, r are now to be considered as functions of the angle v.

The angle T'PA being the supplement of the sum of PTA and PAT; that is, of $v + t$, we have (ALGEBRA, art. 236 and 242),

$$\tan \text{angle T'PA} = -\tan(v + t) = \frac{\tan v + \tan t}{\tan v \tan t - 1}.$$

$$\text{Now } \tan v = \frac{y}{x}, \text{ and } \tan t = \frac{\text{PQ}}{\text{TQ}} = -\frac{dy}{dx};$$

$$\text{therefore } \tan \text{T'PA} = \frac{\frac{y}{x} - \frac{dy}{dx}}{-\frac{ydy}{xdx} - 1} = \frac{xdy - ydx}{xdx + ydy}.$$

$$\text{Again, } \frac{xdy - ydx}{x^2} = d\left(\frac{y}{x}\right) = d\,(\tan v) = \frac{dv}{\cos^2 v},$$

$$\text{therefore } xdy - ydx = dv\frac{x^2}{\cos^2 v} = r^2 dv;$$

$$\text{and } xdx + ydy = \tfrac{1}{2}d\,(x^2 + y^2) = \tfrac{1}{2}d\,(r^2) = rdr;$$

$$\text{therefore } \tan \text{T'PA} = \frac{r^2 dv}{rdr} = \frac{rdv}{dr};$$

and since by trigonometry T'A = AP tan TPA, therefore

$$\text{subtangent T'A} = \frac{dv}{dr}r^2;$$

also, since T'A : AP = AP : AD; therefore

$$\text{subnormal AD} = \frac{dr}{dv}.$$

Ex. Let the curve PH be the spiral of Archimedes, the nature of which is defined by the equation $2\pi r = av$, where $\pi = 2$ right angles, and a is a given line, viz. the value of r when $v = 2\pi$. In this case

$$\text{subtangent} = \frac{dv}{dr}\,.\,r^2 = \frac{2\pi r^2}{a}.$$

68. In some curves the segment of the axis between the origin of the co-ordinates and the tangent increases with the variable x, and may exceed any given line. In others the tangent cuts the axis always at a finite distance from the origin; it is then an *asymptote* to the curve. If from the subtangent QT $= \frac{dx}{dy}y$ (fig. 8) the absciss AQ $= x$ be subtracted, the remainder $\frac{dx}{dy}y - x$ is the general expression for AT. Now if when x is infinite this expression is finite, we may conclude that the curve has asymptotes; but if it be infinite, the curve has no asymptotes.

In the conic hyperbola we found (ex. 3, art. 66) $\frac{dx}{dy}y = x - \frac{a^2}{x^2}$; therefore $\frac{dx}{dy}y - x = -\frac{a^2}{x^2}$; when x is infinite, the expression $-\frac{a^2}{x} = 0$, hence it follows that the hyperbola has an asymptote which passes through the centre.

In the parabola, ex. 1, we found $\frac{dx}{dy}y = \frac{2y^2}{a}$, therefore

Direct Method.

$\frac{dx}{dy}y - x = \frac{2y^2}{a} - x = 2x - x = x$. When x is infinite this quantity is also infinite, therefore the parabola has no asymptote.

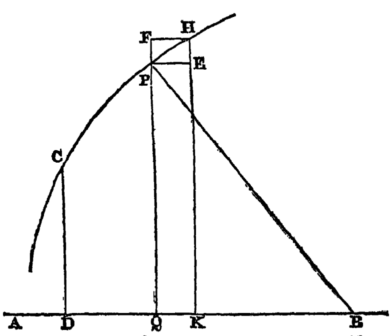
The method of drawing tangents to curves is an important branch of the theory of curve lines. It serves also to determine their greatest and least ordinates (which may also be found by the theory of *maxima* and *minima*), and many other circumstances relating to their figure.

Differential of the Area of a Curvilineal Space, and of the Arc of a Curve.

69. In curve lines it is convenient to consider x, one of the co-ordinates, as an independent variable quantity; and any area having an arc of the curve for a boundary, also the arc, and in general every other variable quantity connected with the curve, as functions of that variable. If the curve be expressed by a polar equation, the angle which the revolving radius makes with the variable may be taken as the independent variable, and the co-ordinates and other variable quantities related to the curve as functions of that angle.

We begin by investigating a formula for the area.

Fig. 11.



Let AB be the axis of any curve CP, A and C given points in the axis and curve, PQ, HK any two variable ordinates, and CD an ordinate given in position at the given point C; draw PE and HF perpendiculars to HK, PQ.

Put $AQ = x$, $PQ = y$, *curvilineal space* $PQDC = s$;
$AK = x'$, $HK = y'$, $HKDC = s'$;
then $QK = x' - x$, and $PHKQ = s' - s$.

The space PHKQ is greater than the rectangle PEKQ, but less than the rectangle FHKQ (supposing y to increase from the position PQ to HK), therefore,

$$s' - s > (x' - x)\,y, \quad s' - s < (x' - x)\,y';$$

$$\text{and } \frac{s' - s}{x' - x} > y, \quad \frac{s' - s}{x' - x} < y'.$$

Hence, since when HK approaches to coincidence with PQ, y' approaches to equality with y, we have

$$\frac{ds}{dx} = \lim.\,\frac{s' - s}{x' - x} = y,$$

and $ds = ydx$..............................(1).

Thus it appears that *The differential of a curvilineal area is the product of the ordinate and the differential of the absciss.*

In the formula just found, the ordinates have been supposed perpendicular to the axis. If they be oblique, let α be the angle of inclination; then $s' - s$ will be greater than $(x' - x)\,y \,.\, \sin\alpha$, but less than $(x' - x)\,y' \,.\, \sin\alpha$; and hence, reasoning as before, we find

$ds = \sin\alpha \,.\, ydx$..........................(2).

70. To find a formula applicable when the nature of the curve is expressed by a polar equation, let B be the pole, and PB the variable radius.

Direct Method.

Put $PB = r$, the angle $PBQ = v$, and the curvilineal space $PCDB = s$; also let $BQ = x$, $PQ = y$, then

$$ds = d\,(\text{space } CDQP) + d\,(\text{triangle } PQB).$$

Now d (space CDQP) $= -\,ydx$, which is negative, because x decreases when the space increases; and d (triangle PQB) $= d\left(\frac{1}{2}xy\right) = \frac{1}{2}ydx + \frac{1}{2}xdy$; therefore,

$$ds = -\,ydx + \tfrac{1}{2}ydx + \tfrac{1}{2}xdy = \tfrac{1}{2}\,(xdy - ydx)$$
$$= \tfrac{1}{2}x^2 d\left(\frac{y}{x}\right) \text{ (art. 12).}$$

But in the right-angled triangle PBQ,

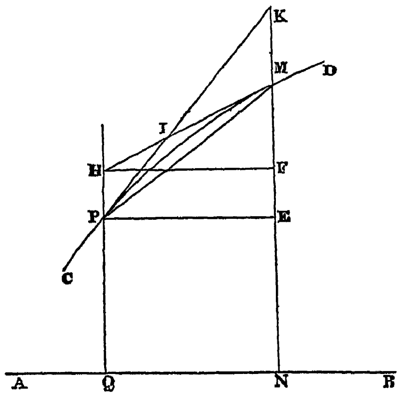
$$BQ = x = r\cos v, \quad \frac{y}{x} = \tan v, \quad d\left(\frac{y}{x}\right) = \frac{dv}{\cos^2 v} \text{ (art. 22);}$$

hence $ds = \frac{1}{2}r^2 dv$..........................(3).

In this case *The differential of the area is half the product of the square of the revolving radius, and the differential of the angle which it makes with the axis.*

71. We have already found (art. 23) various expressions for the differential of the arc of one particular curve, viz. the circle. We shall now investigate general expressions for the differential of the arc of any curve. For this purpose it will be convenient to establish the following geometrical proposition.

Fig. 12.



Let CPMD be a curve, that between the points P and M continually approaches to or continually recedes from an axis AB. Let PQ, MN be ordinates to the axis at the extremities of the arc PM, and PK, MH tangents to the curve at the points P, M, meeting the ordinates in K and H: The length of the arc is always of an intermediate magnitude between the lengths of the tangents PK, MH.

Draw the chord PM, and let I be the intersection of the tangents. It is easy to see that PK, one of the tangents, meets the parallel ordinates in an angle K more acute than M, the angle made by the chord PM and ordinate MN; and the other in an angle H less acute; therefore the chord will be less than the former and greater than the latter. Now the arc is greater than the chord; therefore MH, the least of the tangents, is less than the arc PM.

Again, in the two triangles PIH, MIK, it is evident that the two parts PI, IK, of the longest tangent, are respectively greater than HI, IM, those of the shorter; therefore PK is longer than the sum of PI and IM; but the arc PM is by an axiom of geometry less than the sum of PI and IM, therefore the tangent PK is greater than the arc PM.

72. Let A be a given point in the axis, and C in the curve; draw PE, HF parallel to AB; put $AQ = x$, $AN = x'$, $PQ = y$, $CP = z$, $CM = z'$; then $PE = x' - x$, and arc $PM = z' - z$. Because $PM = z' - z$ is less than PK, but greater than MH, therefore

$$\frac{z'-z}{x'-x}<\frac{PK}{PE}, \text{ and } \frac{z'-z}{x'-x}>\frac{HM}{HF}.$$

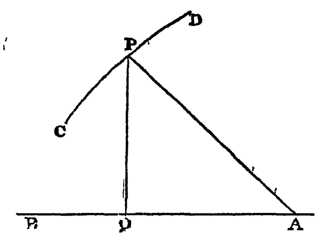
Now $\frac{PK}{PE}$ and $\frac{HM}{HF}$ are the secants of the angles KPE and MHF; therefore the ratio $\frac{z'-z}{x'-x}$ is expressed by a quantity less than the secant of one of these angles, and greater than the secant of the other angle. Suppose now $z'-z$ and $x'-x$, the terms of the ratio, to be continually diminished; the angles at H and P will approach to equality, and at last become equal, therefore the limit of the ratio, viz. $\frac{dz}{dx}$, is equal to the secant of the angle KPE; but it was shown (art. 65) that the tangent of the angle which a line touching a curve makes with the axis, or any line parallel to the axis, is equal to $\frac{dy}{dx}$, and consequently its secant to $\sqrt{1+\frac{dy^2}{dx^2}}$; therefore

$$\frac{dz}{dx}=\sqrt{1+\frac{dy^2}{dx^2}} \text{ and } dz=\sqrt{dx^2+dy^2}\ldots\ldots\ldots\ldots(1)$$

Hence it appears that *The square of the differential of the arc of a curve is equal to the sum of the squares of the differentials of its rectangular co-ordinates.*

73. In the case of curves expressed by a polar equation, let A be the given point about which the variable radius

Fig. 13.



AP turns; put v for the variable angle which the line AP $= r$ makes with AB, a line given in position; let the rectangular co-ordinates be AQ $= x$, PQ $= y$; then

$$x=r\cos v,\ y=r\sin v;$$

$$dx=-r\sin v\,dv+\cos v\,dr=-ydv+\frac{x}{r}dr;$$

$$dy=r\cos v\,dv+\sin v\,dr=xdv+\frac{y}{r}dr;$$

$$dx^2=y^2dv^2+\frac{x^2}{r^2}dr^2-\frac{2xy}{r}dvdr;$$

$$dy^2=x^2dv^2+\frac{y^2}{r^2}dr^2+\frac{2xy}{r}dvdr;$$

$$\text{therefore, } dx^2+dy^2=(x^2+y^2)\left(dv^2+\frac{dr^2}{r^2}\right).$$

But $dx^2+dy^2=dz^2$, and $x^2+y^2=r^2$;
therefore, $dz^2=r^2dv^2+dr^2$,

$$\text{and } dz=\sqrt{r^2dv^2+dr^2}\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

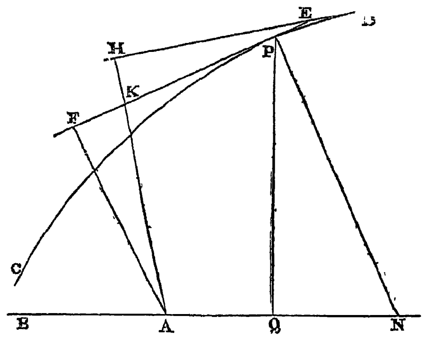
This formula gives the differential of an arc of a curve in terms of the differentials of the variable *radius vector,* and of the angle which it makes with the axis.

74. We shall now give a method of defining a curve by a polar equation, which leads to a simple and elegant expression for the differential of an arc of the curve.

Let CPD be any curve, and A a given point in AB, a line given by position; draw a tangent PF at any point P in the curve, and a perpendicular AF from the given point A on the tangent; if now we know the relation between the perpendicular AF, and the angle FAB, which it makes with the line AB, the length of the perpendicular corresponding to any given value of the angle can be found; thus the position of the tangent will be known; the calculus gives a general formula for PF, the segment of the tangent between the point of contact and its intersection with the perpendicular; thus the point of contact P is known, and in this way may any number of points in the curve be determined.

75. Let D be another point in the curve, DH a tangent, and AH a perpendicular on the tangent, and let us put angle FAB $= u$, perp. AF $= p$, tan PF $= t$, arc CP $= z$;
HAB $= u'$, AH $= p'$, DH $= t'$, CD $= z'$

Fig. 14.



From the position of the lines in the figure,

$$\begin{aligned}HD-FP&=HE+ED-(FK+KE-EP)\\&=PE+ED-FK-(KE-HE).\end{aligned}$$

By trigonometry, FK $=$ AF . tan FAK $= p\tan(u'-u)$; and because in the equiangular triangles AFK, EHK, the angles at A and E are equal, therefore HE $=$ KE . cos $(u-u')$; hence the above equation may be expressed thus,

$$t-t'=PE+ED-p.\tan(u'-u)-\{1-\cos(u'-u)\}KE;$$

and dividing by $u'-u$,

$$\frac{t'-t}{u'-u}=\frac{PE+ED}{u'-u}-p.\frac{\tan(u'-u)}{u'-u}-\frac{1-\cos(u'-u)}{u'-u}KE.$$

Suppose now the point D to approach to coincidence with P, we have these limits to the ratios:

$$\lim.\frac{t'-t}{u'-u}=\frac{dt}{du};\qquad \lim.\frac{PE+ED}{u'-u}=\frac{dz}{du};$$

$$\lim.\frac{\tan(u'-u)}{u'-u}=1;\qquad \lim.\frac{1-\cos(u'-u)}{u'-u}$$

$$=\lim.\frac{2\sin^2\frac{1}{2}(u'-u)}{u'-u}=0;$$

hence, on the whole,

$$\frac{dt}{du}=\frac{dz}{du}-p, \text{ and } dz=dt+pdu,$$

$$\text{or } d(z-t)=pdu.$$

In the figure from which the formula has been investigated, the arc and tangent lie in the same direction from the point of contact. If they had proceeded in contrary directions, the formula would have been $d(z+t)=pdu$, so that, in general,

$$d(z\mp t)=pdu\ldots\ldots\ldots\ldots\ldots(3)$$

The differential of the arc may be expressed independently of t; for

$$AH-AF=KH+AK-AF;$$

Now KH $=$ HE . tan HEK $=$ HE tan $(u'-u)$, and AF $=$ AK cos $(u'-u)$; therefore, dividing by $u'-u$, we have

$$\frac{p'-p}{u'-u} = \mathrm{HE}\,\frac{\tan(u'-u)}{u'-u} + \frac{1-\cos(u'-u)}{u'-u}\,\mathrm{AK}:$$

and, passing to the limits, observing that lim. HE $= t$,

$$\text{lim.}\frac{\tan(u'-u)}{u'-u} = 1, \text{ and lim.}\frac{1-\cos(u'-u)}{u'-u} = 0,$$

we find $\dfrac{dp}{du} = t$; if the tangent and arc lie in contrary directions, then $-\dfrac{dp}{du} = t$, so that, including both cases in one formula, $t = \pm\dfrac{dp}{du}$.

The sign $+$ is to be taken when the arc and tangent lie in the same direction, but the sign $-$ when they have contrary directions; and because $dt = \pm\dfrac{d^2p}{du}$, therefore in every curve

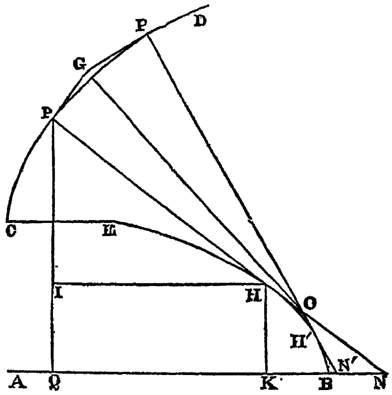
$$dz = pdu + \frac{d^2p}{du^2}\,du = \left(p + \frac{d^2p}{du^2}\right)du \ldots\ldots\ldots\ldots (4)$$

This is the formula which was to be found.

Generation of Curves by Evolution: Radius of Curvature: Evolutes.

76. The method of generating curves by evolution is a geometrical theory invented by Huygens, and given in his *Horologium Oscillatorium.* He explained it upon geometrical principles, for his work appeared many years before the calculus was invented.

Fig. 15.



Let BHE be a model of a plane curve made of a solid material, having some thickness, and let one end of a thread HEC be fastened at a point B on the edge of the model, and applied along its convexity, so as to coincide with it entirely between B and E, the remaining portion EC of the thread forming a straight line touching the curve at E. Suppose now the thread to be gradually unlapped from the curve BE, keeping it always tight; the end C will now describe another curve CPD.

All curves, in which the curvature is neither infinitely great nor infinitely small, may be generated in this way by the evolution of a thread from another curve.

77. The curve EHB, by means of which the curve CPD is generated, is called its EVOLUTE; and the curve CPD thus generated by evolution, is called the INVOLUTE of the other curve.

From the way in which the involute is generated from its evolute, we may infer,

(1.) That PH, the part of the thread disengaged from the arc EH, is a tangent to the evolute at H.

(2.) That the line PH is perpendicular to a tangent to the curve CPD at P, and that at the same time it describes an element of the curve, and an element of a circle whose momentary centre is H and radius HP.

(3.) That to a certain extent the part of the involute adjoining to P, and towards C, is *more* incurvated than a circle whose radius is PH; because, supposing P to proceed towards C, the variable radius PH is gradually becoming shorter. On the other hand, a portion of the curve from P towards D is *less* incurvated than a circle whose radius is CP, because the generating radius is continually becoming longer.

(4.) That since the curvature of the involute on one side of P, and adjoining to it, is less than that of a circle whose radius is PH, and the curvature on the other side of P is greater, it follows that at the point P the curvature of the involute is exactly the same as that of a circle described with the radius HP. The point H is therefore called the *centre of curvature* of the curve CPD in the point P; and PH, its *radius of curvature* at that point; and a circle described with the line PH is the *circle of equal curvature* with the curve at the point P. From the close union of the circle and curve they have been said to *osculate.* It must, however, be kept in mind that the two curves have no common segment; they meet in a geometrical point at P, and separate on both sides of it. We may also infer that the circle of curvature has a more intimate contact with the curve than any other circle that passes through that point.

(5.) That the evolute of a curve is the *locus* of the centre of curvature of every point in the curve.

78. We shall now investigate general formulæ for the radius of curvature, and for the evolute of any curve, by which these may be found when the nature of the curve is known.

Let AB be the common axis of the involute CPD, and its evolute EHB, and A the origin of co-ordinates; let H be the centre, and PH the radius of curvature at P; and H′ the centre, and P′H′ the radius of curvature of another point P′, near the former. Let the radii produced, if necessary, meet the axis in N and N′; and let O be the point in which they intersect each other.

Put AQ $= x$, PQ $= y$, arc CP $= z$, arc CP′ $= z'$, angle PNA $= v$, angle P′N′A $= v'$, rad. of curv. PH $= r$

By trigonometry, PG $=$ OG . sin POG ; P′G $=$ OG . sin P′OG; therefore, $\mathrm{OG} = \dfrac{\mathrm{PG} + \mathrm{P'G}}{\sin \mathrm{POG} + \sin \mathrm{P'OG}}$.

Suppose now the points P′, P to approach continually towards coincidence, the line GO will manifestly have for its limit PH, the radius of curvature at P. The limit of the sum of the tangents PG, P′G will be the arc PP′ $= z' - z$. The limit of the sines of the angles POG, P′OG will be the arcs which measure the angles, and that of the sum of the sines will be the measure of the angle POP $=$ NON $= v' - v$. Hence it appears that $r =$ limit of $\dfrac{z'-z}{v'-v}$, and therefore, that

$$r = \frac{dz}{dv} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

This is our first general expression for the radius of curvature. Put $\dfrac{dy}{dx} = p$, $\dfrac{d^2y}{dx^2} = \dfrac{dp}{dx} = q$.

Because (art. 72) $dz = \sqrt{dx^2 + dy^2} = dx\sqrt{1 + \dfrac{dy^2}{dx^2}}$,

therefore $dz = dx\sqrt{1 + p^2}$.

When treating of tangents to curves, we found (art. 65) that $\tan v = \dfrac{dx}{dy}$, therefore, $\tan v = \dfrac{1}{p}$, $\sec v = \dfrac{\sqrt{1+p^2}}{p}$,

and $d(\tan v) = dv \sec^2 v = -\frac{dp}{p^2}$;

hence, $\frac{1+p^2}{p^2}dv = -\frac{qdx}{p^2}$, and $dv = -\frac{qdx}{1+p^2}$.

If now the values of dz and dv be substituted in our first formula for the radius of curvature, there is obtained

$$r = -\frac{1}{q}(1+p^2)^{\frac{3}{2}} = -\frac{(dx^2+dy^2)^{\frac{3}{2}}}{dxd^2y} \ldots\ldots\ldots\ldots(2)$$

This is a second general formula for the radius of curvature.

Let s denote the normal PN. In the right-angled triangle PQN, by trigonometry, $\sin \mathrm{N} = \frac{\mathrm{PQ}}{\mathrm{PN}}$, that is, $\sin v = \frac{y}{s}$; but since

$$\tan v = \frac{dx}{dy} = \frac{1}{p}, \text{ therefore } \frac{y}{s} = \sin v = \frac{1}{\sqrt{1+p^2}},$$

$$\text{and } \sqrt{1+p^2} = \frac{s}{y}, \text{ and } (1+p^2)^{\frac{3}{2}} = \frac{s^3}{y^3}.$$

Referring now to our second formula, we have

$$r = -\frac{s^3}{qy^3} = -\frac{s^3}{y^3}\cdot\frac{dx^2}{d^2y} \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

This is a third formula for the radius of curvature.

If we suppose the nature of the curve (see fig. 14, art. 74) expressed by an equation between $\mathrm{AF} = p$, a perpendicular from a given point in the axis on a tangent PF, and $\mathrm{FAP} = v$, the angle which that perpendicular makes with the axis, and therefore also equal to the angle which the normal PN makes with the axis; then, since $dz = \left(p + \frac{d^2p}{dv^2}\right)dv$; from formula (1) we get also

$$r = p + \frac{d^2p}{dv^2} \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

This is a fourth formula for the radius of curvature.

79. To determine the nature of the evolute EHB, from any point H in the curve draw HK perpendicular to AB, and HI perpendicular to PQ; and assuming A, the origin of the co-ordinates of the involute also as the origin of those of the evolute, let $\mathrm{AK} = \alpha$, $\mathrm{HK} = \beta$; in the triangle PHI, $\mathrm{HI} = \mathrm{PH}\,.\cos \mathrm{H} = r\cos v$, and $\mathrm{PI} = r \sin v$, therefore

$$\alpha = x + r\cos v, \qquad \beta = y - r \sin v.$$

We have found that $\tan v = \frac{1}{p}$, and therefore

$$\cos v = \frac{p}{\sqrt{1+p^2}}, \quad \sin v = \frac{1}{\sqrt{1+p^2}};$$

hence, combining these with the expressions for r, we have

$$\alpha = x - \frac{p}{q}(1+p^2), \quad \beta = y + \frac{1}{q}(1+p^2);$$

or, substituting for p and q the quantities they denote,

$$\alpha = x - \frac{dy}{dx}\cdot\frac{dx^2+dy^2}{d^2y}, \quad \beta = y + \frac{dx^2+dy^2}{d^2y}.$$

In these formulæ, and in the second and third for the radius of curvature, x is regarded as the independent variable, and y as a function of x.

80. From the way in which a curve may be generated by an evolute, we have a method of finding any number of curves which may be rectified, that is, whose length may be assigned in algebraic terms; for PH, the radius of the curvature, is the sum of the straight line CE, and the arc EH of the evolute. Now we can form innumerable curves whose radius of curvature will be known, therefore, corresponding to every curve whose radius of curvature can be found and expressed in algebraic terms, there is a curve which can be exactly rectified.

81. We shall now give examples of the application of the formulæ.

Ex. 1. Let the curve be a parabola, of which AC is the axis: let c denote the parameter, and let $\mathrm{AQ} = x$, and $\mathrm{PQ} = y$, be the co-ordinates of P, any point in the curve. Let CH be the evolute, and let $\mathrm{AK} = \alpha$, $\mathrm{HK} = \beta$, be the co-ordinates of H, the centre of curvature at P, the radius of curvature being $\mathrm{PH} = r$.

By the nature of the curve, $y^2 = cx$, therefore,

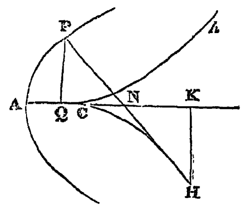
$$\frac{dy}{dx} = p = \frac{c}{2y};\ 1+p^2 = \frac{c^2+4y^2}{4y^2} = \frac{c+4x}{4x};$$

$$\frac{d^2y}{dx^2} = \frac{dp}{dx} = q = -\frac{c}{2}\frac{dy}{dx}\cdot\frac{1}{y^2} = -\frac{c^2}{4y^3};$$

$$r = -\frac{(1+p^2)^{\frac{3}{2}}}{q} = \frac{(c^2+4y^2)^{\frac{3}{2}}}{2c^2} = \frac{(c^2+4cx)^{\frac{3}{2}}}{2c^2}$$

$$= \tfrac{1}{2}\sqrt{\frac{(c+4x)^3}{c}}.$$

Fig. 16.



This is the expression for the radius of curvature by formula (2). If we put the normal $\mathrm{PN} = s$, we have, by formula (3) (art. 78),

$$r = -\frac{s^3}{qy^3} = \frac{4s^3}{c^2}\,. = \frac{s^3}{(\frac{1}{2}c)^2} = \frac{(\text{normal})^3}{(\text{semipar.})^2}.$$

Next, to find the evolute, we have

$$\alpha = x - \frac{p}{q}(1+p^2) = x + \frac{4x+c}{2} = 3x + \tfrac{1}{2}c;$$

$$\beta = y + \frac{1+p^2}{q} = y - \frac{c^2+4y^2}{c^2}y = \frac{-4y^3}{c^2}.$$

Hence $x = \frac{1}{3}(\alpha - \frac{1}{2}c)$, $y = -\left(\frac{c^2\beta}{4}\right)^{\frac{1}{3}}$;

and since, by the nature of the parabola, $cx = y^2$; therefore the equation of the evolute is

$$\beta^2 = \frac{16}{27c^2}\left(\alpha - \frac{c}{2}\right)^3;$$

Take $\mathrm{AC} = \frac{1}{2}c$, then C is a given point; and $\mathrm{CK} = \alpha - \frac{1}{2}c$. Put $\mathrm{CK} = x'$; $\mathrm{HK} = \beta = -y'$, and the equation of the involute becomes

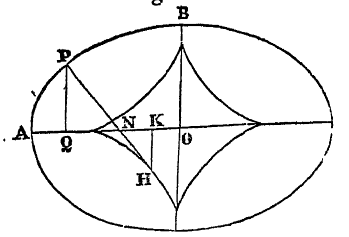
$$y'^2 = \frac{16}{27c}x'^3.$$

Hence it appears that the evolute is the semicubical parabola. This is the first curve that was rectified by the infinitesimal calculus.

Ex. 2. Let the curve be an ellipse, of which $\mathrm{OA} = a$ is the semitransverse axis, and $\mathrm{OB} = b$ the semiconjugate. Let $e = \sqrt{a^2 - b^2}$ be the eccentricity, and, assuming the centre as the origin of co-ordinates, let $\mathrm{OQ} = x$, $\mathrm{PQ} = y$, HP, the radius of curvature at P, $= r$.

The equation of the curve is $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$; or $b^2x^2 + a^2y^2 = a^2b^2$: Hence

Fig. 17.



$$\frac{dy}{dx}=p=-\frac{b^2x}{a^2y};$$

$$1+p^2=\frac{b^2}{a^2}\cdot\frac{a^4-(a^2-b^2)\,x^2}{a^2y^2}=\frac{b^2}{a^2}\cdot\frac{a^4-e^2x^2}{a^2y^2}$$

$$=\frac{b^4+(a^2-b^2)\,y^2}{a^2y^2}=\frac{b^4+e^2y^2}{a^2y^2}.$$

$$\frac{d^2y}{dx^2}=\frac{dp}{dx}=q=-\frac{b^2}{a^2y}+\frac{b^2x}{a^2y^2}\cdot\frac{dy}{dx}=-\frac{b^4}{a^2y^3};$$

$$\frac{(1+p^2)^{\frac{3}{2}}}{q}=\frac{-1}{a^4b}\,(a^4-e^2x^2)^{\frac{3}{2}}=\frac{-1}{ab^4}\,(b^4-e^2y^2)^{\frac{3}{2}}.$$

Hence the radius of curvature

$$r=\frac{1}{a^4b}\,(a^4-e^2x^2)^{\frac{3}{2}}=\frac{1}{ab^4}\,(b^4+e^2y^2)^{\frac{3}{2}}$$

$$=\frac{1}{a^4b^4}\,(a^4y^2+b^4x^2)^{\frac{3}{2}}.$$

The formula $r=-\frac{s^3}{y^3q}$ (where $s=$ the normal PN) gives this other value,

$$r=\frac{a^2}{b^4}\,s^3.$$

Now $\frac{b^2}{a}$ is half the parameter of the transverse axis; therefore $r=\frac{(\text{normal})^3}{(\frac{1}{2}\text{ parameter})^2}$ ....(2)

To find the equation of the evolute, let H be any point in the curve; $OK=\alpha$, and $HK=\beta$, the co-ordinates. The values of p, $1+p^2$, and q, being substituted in the formula (art. 79), we have

$$\alpha=x-\frac{b^2x}{a^2y}\cdot\frac{a^2y^3}{b^4}\cdot\frac{b^2}{a^2}\cdot\frac{a^4-ex^2}{a^2y^2}=\frac{e^2x^3}{a^4}:$$

$$\beta=y-\frac{a^2y^3}{b^4}\cdot\frac{b^4-e^2y^2}{a^2y^2}=\frac{e^2y^3}{b^4}.$$

Let us exchange α and β for x' and y', and we have

$$\frac{x^2}{a^2}=\left(\frac{ax'}{e^2}\right)^{\frac{2}{3}};\quad \frac{y^2}{b^2}=\left(\frac{by'}{e^2}\right)^{\frac{2}{3}}.$$

Observing now that in the ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$, we have for the equation of the evolute

$$\left(\frac{ax'}{e^2}\right)^{\frac{2}{3}}+\left(\frac{by'}{e^2}\right)^{\frac{2}{3}}=1;\ \text{or } (ax')^{\frac{2}{3}}+(by')^{\frac{2}{3}}=(a^2-b^2)^{\frac{2}{3}}.$$

The form of this equation is remarkable from its analogy to that of the ellipse itself. The curve has the form shown in figure 17.

Ex. 3. Let the curve be the cycloid; of which let AA′ be the base, BC the axis, BDC a circle whose diameter is BC. From P any point in the curve, draw PDE perpendicular to the axis, meeting the circle in D; draw PQ perpendicular to the base, and let PH be the radius of curvature.

Since all cycloids are similar figures, we may make the radius of the generating circle $=1$; let $CQ=PE=x$, $PQ=CE=y$, the arc $BD=v$.

By the nature of the cycloid (art. 66, ex. 4),

$$x=v+\sin v,\quad y=1-\cos v,$$

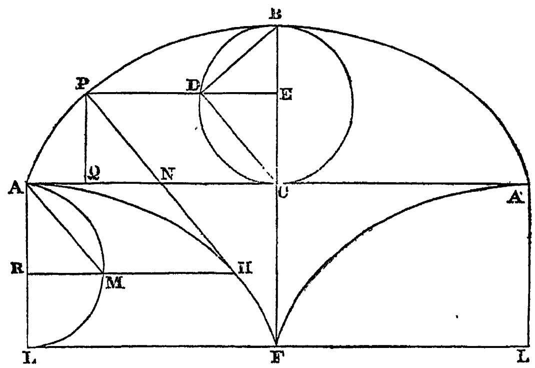
therefore $dx=dv\,(1+\cos v)$, $dy=dv\sin v$,

$$\frac{dy}{dx}=p=\frac{\sin v}{1+\cos v};\ 1+p^2=\frac{2}{1+\cos v},\ dp=\frac{dv}{1+\cos v};$$

$$\frac{d^2y}{dx^2}=\frac{dp}{dx}=q=\frac{1}{(1+\cos v)^2},$$

Hence r, the rad. of cur. $=-\frac{(1+p^2)^{\frac{3}{2}}}{q}=\sqrt{8\,(1+\cos v)}$.

Fig. 18.



Draw the chord CD, and because $1+\cos v=2\cos^2\frac{1}{2}v$ (ALGEBRA, 249) $=2\sin^2\frac{1}{2}$ arc CD $=\frac{1}{2}$ chord^2 CD.

Therefore, $PH=r=2$ chord CD.

It was shown (art. 66) that a tangent at P is parallel to BD, the chord of the supplement of CD; therefore PH, which is perpendicular to the tangent, is parallel to the chord CD; it is therefore determined in position and magnitude for any given point in the curve.

The evolute AHF may be found by the general formula (art. 79), or otherwise from the expression for PH, the radius of curvature, thus:

Draw AL perpendicular to AC, and equal to BC, but on the opposite side of AC; describe the semicircle AML, and draw HMR perpendicular to AL, cutting the semicircle in M; let PH meet AC in N.

Because CA $=$ semicircumference CDB, and CN $=$ DP $=$ arc BD, therefore AN $=$ arc CD. But because PH $=$ 2CD $=$ 2PN; and therefore PN $=$ NH; the parallels PE, HR are equally distant from CA; and hence CE $=$ RA, and arc CD $=$ arc AM and chord CD $=$ chord AM, also angle DCA $=$ angle CAM. Now CD $=$ PN $=$ NH: therefore AM $=$ NH; but AM is parallel to NH; therefore MH $=$ AN $=$ arc CD $=$ arc AM; and HR $=$ arc AM $+$ sin MR; thus it appears that H is a point in a semicycloid having the same base as the cycloid ABA′. Indeed LAF is just the semicycloidal space CBA′ transferred to the position AHF, the point B being placed at A, and A′ at F. If the other semicycloidal space AB be transferred to the position FA′L′, the arc APB in the position FA′ will form another branch of the evolute, exactly similar to FA, but turned the contrary way.

From what has been found it appears, that if the semicycloids FLA, FL′A′ were placed in a vertical plane, with the point F uppermost, and the semi-bases FL, FL′ in a horizontal line; and if a weight were suspended from F by a thread equal in length to FB, and made to vibrate in that plane, like a pendulum; the weight would manifestly vibrate in an arc of a cycloid. This elegant property of the curve was discovered by Huygens, who also found that the vibrations would be isochronal, that is, performed

in equal times. This is an important proposition in dynamics.

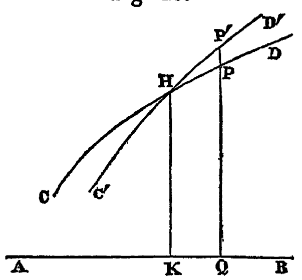
Contact of Curves.

82. The ancient geometers paid particular attention to the contact of straight lines, with the few curve lines which they considered. Apollonius even touched on the contact of circles and the conic sections; for he treated of the shortest line that can be drawn from a given point in the axis to the curve. It is only, however, since the invention of the differential calculus that this branch of geometry has been carried to any considerable extent.

83. The curvature of a circle being the same throughout, it serves as the means of comparing the curvature in different points of a curve. It is, however, easy to understand, that in like manner we might consider the nature of the contact of a parabola, or a curve of any kind whatever, with a proposed curve.

Let $y=f(x)$ and $v=F(x)$ be the equations of two curves CPD, C′P′D′, which have a common axis AB, and the same point A for the origin of co-ordinates. Let x

Fig. 19.



be a common absciss, and y the corresponding ordinate of any point in the curve CD; also v, the like ordinate in the curve C′D′. Suppose now that when x becomes $x+h$, y becomes y', and v becomes v'; by Taylor's theorem,

$$y'=y+\frac{dy}{dx}h+\frac{d^2y}{dx^2}\frac{h^2}{1\,.\,2}+\text{\&c.}$$

$$v'=v+\frac{dv}{dx}h+\frac{d^2v}{dx^2}\frac{h^2}{1.2}+\text{\&c.}$$

Suppose now the curves to have a common point H, at which $y=v$; then, *If the curves be such that* $\frac{dy}{dx}=\frac{dv}{dx}$, *their contact at* P *will be of such a nature, that no third curve can pass between them at that point, unless it has a like property.*

Let HK $=y=v$, KQ $=h$, PQ $=y'$, P′Q $=v'$. Also, let $u=$ HK be the ordinate of a third curve that passes through H, and u' its value, corresponding to AQ $=x+h$, then

$$u'=u+\frac{du}{dx}h+\frac{d^2u}{dx^2}\frac{h^2}{1\,.\,2}+\text{\&c.}$$

We are to prove it to be impossible for the third curve, in leaving the point H, to pass between the arcs HP and HP′, unless $\frac{du}{dx}=\frac{dy}{dx}=\frac{dv}{dx}$. For suppose it possible, then, because in general

$$PP'=y'-v'=y-v+\left(\frac{dy}{dx}-\frac{dv}{dx}\right)h+\left(\frac{d^2y}{dx^2}-\frac{d^2v}{dx^2}\right)\frac{h^2}{2}+\text{\&c.}$$

and, because at the point H, $y=v$; and, in this particular case, $\frac{dy}{dx}=\frac{dv}{dx}$, we have

$$y'-v'=\left(\frac{d^2y}{dx^2}-\frac{d^2v}{dx^2}\right)\frac{h^2}{2}+\left(\frac{d^3y}{dx^3}-\frac{d^3v}{dx^3}\right)\frac{h^3}{6}+\text{\&c.}$$

This is the general expression for P′P′, the difference between the ordinates of the curves CD, C′D′, whatever be the magnitude of KQ $=h$.

In like manner, the difference between y', the ordinate of the first curve, and u', that of the third, will be generally expressed by

$$y'-u'=y-u+\left(\frac{dy}{dx}-\frac{du}{dx}\right)h+\left(\frac{d^2u}{dx^2}-\frac{d^2u}{dx^2}\right)\frac{h^2}{2}+\text{\&c.}$$

which, on the hypothesis that $y=u$, becomes

$$y'-u'=\left(\frac{dy}{dx}-\frac{du}{dx}\right)h+\left(\frac{d^2y}{dx^2}-\frac{d^2u}{dx^2}\right)\frac{h^2}{2}+\text{\&c.}$$

Now, if it were possible that the third curve, in leaving the common point H, could pass between the other two, we should, to a certain extent from the point H, have $y'-v'$ greater than $y'-u'$, that is, after dividing the expressions for $y'-v'$ and $y'-u'$ by h,

$$\left(\frac{d^2y}{dx^2}-\frac{d^2v}{dx^2}\right)\frac{h}{2}+\left(\frac{d^3y}{dx^3}-\frac{d^3v}{dx^3}\right)\frac{h^2}{6}+\text{\&c.}$$
$$>\frac{dy}{dx}-\frac{du}{dx}+\left(\frac{d^2y}{dx^2}-\frac{d^2u}{dx^2}\right)\frac{h}{2}+\text{\&c.}$$

And this equation ought to hold true, however small the line KQ $=h$ be taken. But h may be taken so small, that all the terms in the expression for $y'-v'$ shall be less than any assignable quantity, while those of $y'-u'$ continually approach to $\frac{dy}{dx}-\frac{du}{dx}$ as a limit, which by hypothesis is not equal to zero. Now these two conclusions are incompatible with each other; therefore it is impossible that the third curve can pass through the point P between the other two, when $\frac{dy}{dx}$ is not equal to $\frac{du}{dx}$.

If, however, $\frac{dy}{dx}=\frac{du}{dx}$, then the third curve may pass between the other two; for it will only be necessary that

$$\frac{d^2y}{dx^2}-\frac{d^2v}{dx^2}>\frac{d^2y}{dx^2}-\frac{d^2u}{dx^2},\ \text{that is,}\ \frac{d^2u}{dx^2}>\frac{d^2v}{dx^2},$$

which is evidently possible.

84. Again, if there be two curves whose equations are $y=f(x)$, $v=F(x)$, and which have a common ordinate $y=v$, and if they be such, that

$$\frac{dy}{dx}=\frac{dv}{dx},\qquad \frac{d^2y}{dx^2}=\frac{d^2v}{dx^2};$$

then no third curve of which the equation is $u=\varphi(x)$, and which has a common ordinate with the other two, can pass between them, unless at the same time

$$\frac{dy}{dx}=\frac{du}{dx},\qquad \frac{d^2y}{dx^2}=\frac{d^2u}{dx^2}.$$

This proposition is proved exactly in the same way as that in last article, by means of Taylor's theorem. These are particular cases of a general proposition relating to the contact of curves which may be stated thus: If two curves have a common absciss and ordinate, and if the differential co-efficients of the first order of the ordinates be equal, no third curve passing through their intersection can go between them, unless the differential co-efficient of its ordinate, corresponding to the same absciss, be equal to the differential co-efficients of their ordinates. And if, besides their first differential co-efficients, their second differential co-efficients be equal, then no third curve passing through their intersection can go between them, unless the first and second differential co-efficients of its ordinate be equal to the first and second differential co-efficients of the two curves, and so on to differential co-efficients of all orders.

Direct Method.

In fact, the two curves meet only in the point in which their ordinates are the same, and the equality of the differential co-efficients merely indicates that no other curve in which the same equality does not take place can pass between them.

From what has been shown, it appears that the contacts of curve lines may be distinguished into different orders. The degree of contact in which the ordinates and also the first differential co-efficients are equal, may be called a *Contact of the first order*; when, in addition to these, the second differential co-efficients are equal, it is a *Contact of the second order*; and so on.

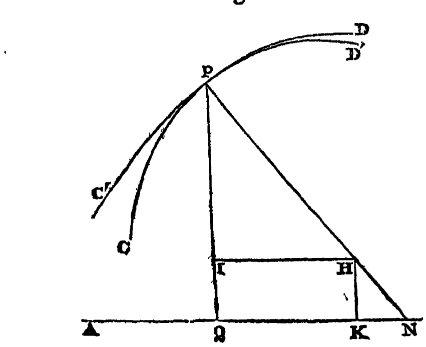
85. In illustration of this theory of contacts, let us consider the nature of the contact of any curve HPK (see fig. 6), with a straight line PT. Let A be the common origin of the co-ordinates. In the curve, let $AB = x$, $PB = y$. Its nature will be expressed by an equation $y = f(x)$. In the straight line, let $TA = c$, $AB = x$, $PB = v$, angle $PTB = \alpha$; the equation of the straight line is $v = (c + x)\tan\alpha$. The hypothesis that the curve and straight line have a common point, gives $y = v$; and the equation of the straight line, considering that c and α must be regarded as constants, gives $\frac{dv}{dx} = \tan\alpha$; now, by our theory, $\frac{dy}{dx} = \frac{dv}{dx}$, therefore $\frac{dy}{dx} = \tan\alpha$. This result coincides with what was found in art. 65; and it gives the sub-tangent

$$BT = \frac{y}{\tan\alpha} = \frac{dx}{dy}y.$$

It is impossible that any straight line can pass between the straight line PT and the curve; for, if possible, let the straight line PS pass between them, and meet the axis in S. Put $AS = c'$, $AB = x$, $PB = u$, the angle $PSB = \alpha'$. The equation of the straight line PS is $u = (c' + x)\tan\alpha'$; and hence $\frac{du}{dx} = \tan\alpha'$. Now, that the line PS may pass between PT and the curve, we should have $\frac{du}{dx} = \frac{dv}{dx} = \frac{dy}{dx}$ (art. 83); therefore, $\tan\alpha' = \tan\alpha$, and $\alpha' = \alpha$; thus it appears that the lines PS, PT must coincide; therefore the straight line PT is a tangent to the curve, in the strictest sense.

86. Let us next consider the nature of the contact of a circle and any curve. Let CPD be the curve, and C′PD′ a circle referred to the same axis AK, in which A is the common origin of the co-ordinates. In the curve CPD let $AQ = x$, $PQ = y$. Let H be the centre of the circle; draw the radius PH, and produce it to meet the axis in N, and draw HI, HK perpendicular to PQ and AQ. Put $AQ = x$, $PQ = v$, these being co-ordinates of P any point in the circumference of the circle; and put $AK = \alpha$, $HK = \beta$, the co-ordinates of its centre; and $PH = r$ its radius.

Fig. 20.



The equation of the curve CPD may be expressed generally by $y = f(x)$. And, since $IH = \alpha - x$, $PI = v - \beta$, and $PH = r$, the equation of the circle will be

$$(\alpha - x)^2 + (v - \beta)^2 = r^2 \quad\text{.................(1)}$$

A contact of the first degree requires that $\frac{dy}{dx} = \frac{dv}{dx}$. Now, observing that α, β, and r must be considered as constants, we have $\frac{dv}{dx} = \frac{\alpha - x}{v - \beta}$, hence and because $y = v$,

$$\frac{dy}{dx} = \frac{\alpha - x}{y - \beta} \quad\text{.....................(2)}$$

The second side of this formula expresses the trigonometrical tangent of the angle HPI. Hence (art. 65) the line PN is a normal to the curve at P, and the circle and curve have a common tangent at that point. By a second differentiation

$$\frac{d^2v}{dx^2} = -\frac{1}{v - \beta} - \frac{\alpha - x}{(v - \beta)^2}\cdot\frac{dv}{dx} = -\frac{(\alpha - x)^2 + (v - \beta)^2}{(v - \beta)^3}.$$

Now, that the circle and curve may have a contact of the second degree of closeness, it is necessary that $\frac{d^2v}{dx^2} = \frac{d^2y}{dx^2}$, therefore, observing that $v = y$, and that $(\alpha - x)^2 + (v - \beta)^2 = r^2$, we have

$$\frac{d^2y}{dx^2} = \frac{-r^2}{(y - \beta)^3} \quad\text{.......................(3)}$$

The three equations (1), (2), (3) serve to determine r, the radius of the circle, and α, β the co-ordinates of its centre. From the first and second we get

$$\alpha - x = \frac{r\,dy}{(dx^2 + dy^2)^{\frac{1}{2}}};\quad y - \beta = \frac{r\,dx}{(dx^2 + dy^2)^{\frac{1}{2}}};$$

and from these, and equation (3), we get

$$r = -\frac{(dx^2 + dy^2)^{\frac{3}{2}}}{dx\,d^2y};$$

$$\alpha = x - \frac{dy}{dx}\cdot\frac{dx^2 + dy^2}{d^2y};\quad \beta = y + \frac{dx^2 + dy^2}{d^2y}.$$

These expressions for α, β, and r determine the position and magnitude of the circle; they are manifestly identical with the radius of the circle of equal curvature, and the co-ordinates of its centre formerly found (art. 78 and 79). Hence we conclude, that the circle of equal curvature with a curve in any point, determined by the theory of evolutes, is identical with a circle, having with the curve a contact of the second order.

And since it appears that only one circle can have with a curve a contact of the second order, and that no circle can pass between that circle and the curve, therefore the same must be true of the circle of equal curvature, found by the theory of evolutes.

87. From what has been shown in regard to the degrees of contact of a straight line and circle with a curve, it appears that these depend on the number of constants which enter into the equation of the touching line. The equation of a straight line contains two constants, and it admits of one order of contact only. The equation of a circle has three constants, and it admits of a contact of the second order. It is easy to see that the number of differential co-efficients that can be made equal in the two curves will always be one less than the number of constants in the touching curve. The equation of a parabola is $y = \alpha + \beta x + \gamma x^2$. This and the differential equations which may be deduced from it serve to determine the three constants α, β, γ, and thence the parabola of equal curvature; but since there are only two differential co-efficients, the parabola can have a contact of the first and

also of the second order with any curve, but no higher order of contact. A cubic parabola, whose equation is $y = \alpha + \beta x + \lambda x^2 + \delta x^3$, may, however, have a contact of the third order, because it involves four constants, and so on.

Development and Differentiation of Functions containing two Variables.

88. Let u be a function of two independent variables, x and y; for example, $u = ax^2 + bxy + cy^2$, and in general $u = f(x, y)$. Suppose now that x changes its value, and becomes $x + h$, and that y becomes $y + k$, so that u' being the new value of the function, $u' = f(x+h, y+k)$. It is proposed to expand u' into a series of terms proceeding by the integer powers of h and k. In particular cases the method of proceeding is obvious; a general formula may be found by Taylor's theorem as follows.

It is easy to see that the result will be the same whether we substitute at once $x + h$ for x, and $y + k$ for y, in the function u, and then expand it; or, otherwise, first substitute $x + h$, then expand the function, according to the powers of h, and in this first result put $y + k$ for y, and afterwards expand it into terms proceeding by the powers of k; or we may reverse this process, beginning with the expansion according to the powers of k, and ending with that proceeding by the powers of h.

Resuming the function $u = f(x, y)$; when x becomes $x + h$, we have by Taylor's theorem $f(x + h, y) =$

$$u + \frac{du}{dx}h + \frac{d^2u}{dx^2}\frac{h^2}{1.2} + \frac{d^3u}{dx^3}\frac{h^3}{1.2.3} + \text{\&c.}$$

the differentials being taken upon the supposition that x is variable, and y a constant. And in this series y is contained only in the function u, and the differential co-efficients $\frac{du}{dx}, \frac{d^2u}{dx^2}$, &c.

Suppose now that y becomes $y + k$, then, in the series, the function u becomes

$$u + \frac{du}{dy}k + \frac{d^2u}{dy^2}\frac{k^2}{1.2} + \frac{d^3u}{dy^3}\frac{k^3}{1.2.3} + \text{\&c.};$$

the function $\frac{du}{dx}$ becomes

$$\frac{du}{dx} + \frac{d\frac{du}{dx}}{dy}k + \frac{d^2\frac{du}{dx}}{dy^2}\frac{k^2}{1.2} + \frac{d^3\frac{du}{dx}}{dy^3}\frac{k^3}{1.2.3} + \text{\&c.};$$

the function $\frac{d^2u}{dx^2}$ becomes

$$\frac{d^2u}{dx^2} + \frac{d\frac{d^2u}{dx^2}}{dy}k + \frac{d^2\frac{d^2u}{dx^2}}{dy^2}\frac{k^2}{1.2} + \frac{d^3\frac{d^2u}{dx^2}}{dy^3}\frac{k^3}{1.2.3} + \text{\&c.};$$

the function $\frac{d^3u}{dx^3}$ becomes

$$\frac{d^3u}{dx^3} + \frac{d\frac{d^3u}{dx^3}}{dy}k + \frac{d^2\frac{d^3u}{dx^3}}{dy^2}\frac{k^2}{1.2} + \frac{d^3\frac{d^3u}{dx^3}}{dy^3}\frac{k^3}{1.2.3} + \text{\&c.};$$

and in the differentiation of the functions $u, \frac{du}{dx}, \frac{d^2u}{dx^2}$, &c., y is taken as the variable, and x as a constant. By making the proper substitutions, we have $f(x + h, y + k)$ expressed by the series

$$u + \frac{du}{dy}k + \frac{d^2u}{dy^2}\frac{k^2}{1.2} + \text{\&c.}$$

$$+ \frac{du}{dx}h + \frac{d\frac{du}{dx}}{dy}hk + \text{\&c.}$$

$$+ \frac{d^2u}{dx^2}\frac{h^2}{1.2} + \text{\&c.}$$

$$+ \text{\&c.}$$

If the substitutions of $x + h$ for x, and $y + k$ for y, had been made in an inverse order, we would have had $f(y + k, x + h)$ equal to

$$u + \frac{du}{dx}h + \frac{d^2u}{dx^2}\frac{h^2}{1\cdot2} + \text{\&c.}$$

$$+ \frac{du}{dy}k + \frac{d\frac{du}{dy}}{dx}hk + \text{\&c.}$$

$$+ \frac{d^2u}{dy^2}\frac{k^2}{1\cdot2} + \text{\&c.}$$

The order in which the substitutions are made being arbitrary, the two developments of $f(x + h, y + k)$ must be identical, consequently the terms containing the same products of h and k must be equal. Thus, passing over the terms which are the same, we have

$$\frac{d\frac{du}{dx}}{dy} = \frac{d\frac{du}{dy}}{dx}.$$

89. This formula proves an important theorem in the calculus, namely, if a function u of two independent variables x and y be twice differentiated, first, on the hypothesis that x is variable and y constant, and then the result on the supposition that y is variable and x constant. And again, if the order of the differentiations be reversed, that is, if y be made variable and x constant, and then x variable and y constant, the final result either way will be the very same.

The symbol $\frac{d\frac{du}{dx}}{dy}$, which expresses the result of two differentiations performed on u, a function of two variables x and y (the first on the supposition that x is variable and y constant, and the second on the reverse supposition), may conveniently be simplified into $\frac{d^2u}{dxdy}$. By this notation the theorem just enunciated in words will be expressed in symbols thus:

$$\frac{d^2u}{dxdy} = \frac{d^2u}{dydx}.$$

By continuing the two developments a term farther, we would have arrived at the conclusion that (having regard to the notation just premised),

$$\frac{d^3u}{dxdydx} = \frac{d^3u}{dx^2dy} = \frac{d^3u}{dydx^2};$$

$$\text{and that } \frac{d^3u}{dxdy^2} = \frac{d^3u}{dy^2dx}, \text{ \&c.}$$

Suppose, for example, that $u = x^3y^5$, then

$$\frac{du}{dx} = 3x^2y^5, \qquad \frac{du}{dy} = 5x^3y^4,$$

$$\frac{d^2u}{dxdy} = 15x^2y^4, \quad \frac{du}{dydx} = 15x^2y^4,$$

$$\frac{d^3u}{dx^2dy} = 30xy^4, \quad \frac{d^3u}{dydx^2} = 30xy^4.$$

Adopting now the abbreviated notation, when $u = f(x, y)$, we have $f(x + h, y + k) =$

$$u + \frac{du}{dx}h + \frac{d^2u}{dx^2}\frac{h^2}{2} + \frac{d^3u}{dx^3}\frac{h^3}{2.3} + \text{\&c.}$$

$$+ \frac{du}{dy}k + \frac{d^2u}{dydx}hk + \frac{d^3u}{dydx^2}\frac{h^2k}{2} + \text{\&c.}$$

$$+ \frac{d^2u}{dy^2}\frac{k^2}{2} + \frac{d^3u}{dy^2dx}\frac{hk^2}{2} + \text{\&c.}$$

$$+ \frac{d^3u}{dy^3}\frac{k^3}{2.3} + \text{\&c.}$$

This is the complete development of the function u.

90. Supposing u to be any function of x, and that x becomes $x+h$, by which u becomes $u+ph+qh^2+$&c., or (considering h as the *differential* of x) $u+pdx+qdx^2+$ &c. We have defined the *differential* of u to be the term pdx, viz. that which contains the simple power of h or dx, and called the function p, the *differential co-efficient,* representing it by $\frac{du}{dx}$. We may now extend these definitions to $f(x, y)$, a function of two variables, and changing h into dx and k into dy in the development of the function, we shall have

$$df(x, y) = du = \frac{du}{dx}dx + \frac{du}{dy}dy.$$

From this it appears that the *complete* differential of a function of two variables consists of two parts, viz. $\frac{du}{dx}dx$, or the differential taken on the supposition that x alone is variable, and $\frac{du}{dy}dy$, or the differential taken when y only is variable.

We may also apply to functions of two variables the rules which have been given (art. 10–23) for those which depend only on one; and for this purpose *we must differentiate the function first with respect to one of its variables, and then with respect to another; and take the sum of the results for the complete differential required.* By this rule

$$d(x+y) = dx + dy$$
$$d(xy) = ydx + xdy,$$
$$d\left(\frac{x}{y}\right) = \frac{dx}{y} - \frac{xdy}{y^2} = \frac{ydx - xdy}{y^2}.$$

Again, let $u = x^my^n$, we have

$$\frac{du}{dx}dx = mx^{m-1}y^ndx, \quad \frac{du}{dy}dy = nx^my^{n-1}dy,$$

$$du = \frac{du}{dx}dx + \frac{du}{dy}dy = x^{m-1}y^{n-1}(mydx + nxdy).$$

91. The manner in which the differentials of functions which depend on more than one variable are written, gives rise to some important remarks. The expression $\frac{du}{dx}dx$ must not be confounded with du, which it might be if u contained only the variable x; the symbol $\frac{du}{dx}$ has in this case a particular meaning, and denotes the differential co-efficient taken on the hypothesis of x only being variable; or it is the quotient of the first term of the development of the difference taken on that supposition divided by the increment dx; and $\frac{du}{dy}dy$ signifies the same with respect to y.

The quantities $\frac{du}{dx}, \frac{du}{dy}$ are commonly called *partial differences* of the first order of the function u, and generally $\frac{d^{m+n}u}{dx^mdy^n}$ represents one of those of the order $m+n$, which arises by differentiating m times in respect of x, and n times in respect of y.

A function of a single variable has only one differential co-efficient of any order; but a function of two variables has two differential co-efficients for the first order, three for the second, &c. These may be deduced from the two first, beginning with

$$du = \frac{du}{dx}dx + \frac{du}{dy}dy;$$

then, taking the differentials of $\frac{du}{dx}$ and $\frac{du}{dy}$, which must be treated as functions of two variables, we have

$$d\frac{du}{dx} = \frac{d^2u}{dx^2}dx + \frac{d^2u}{dydx}dy,$$

$$d\frac{du}{dy} = \frac{d^2u}{dxdy}dx + \frac{d^2u}{dy^2}dy;$$

and since the second differential is nothing more than the differential of the first,

$$d^2u = \frac{d^2u}{dx^2}dx^2 + 2\frac{d^2u}{dxdy}dxdy + \frac{d^2u}{dy^2}dy^2.$$

Here dx and dy are considered as constant quantities, and the differential co-efficients whose denominators contain only the products of dx and dy differently arranged, are considered as identical. By a repetition of this process, an expression may be found for the third differential co-efficient of the function u, and so on to any differential.

92. What has been explained in respect of a function of two independent variables, will apply to a function of any number; thus, if $u = f(t, x, y, z)$, then,

$$du = \frac{du}{dt}dt + \frac{du}{dx}dx + \frac{du}{dy}dy + \frac{du}{dz}dz,$$

where the symbols

$$\frac{du}{dt}, \frac{du}{dx}, \frac{au}{dy}, \frac{du}{dz},$$

denote the differential co-efficients of the function u taken on the supposition that t or x or y or z alone varies.

This notation owes its origin to Fontaine. Euler feared that the differential co-efficient $\frac{du}{dx}$ might be confounded with the ratio of the complete differential du to the differential dx, which is equivalent to

$$\frac{\frac{du}{dt}dt + \frac{du}{dx}dx + \frac{du}{dy}dy + \frac{dz}{dz}dz}{dx},$$

he therefore denoted this ratio by $\frac{du}{dx}$, whilst he expresses the differential co-efficient found by supposing x alone variable by $\left(\frac{du}{dx}\right)$. The nature of the subject, however, in general shows which of the two is intended, and renders this distinction superfluous.

Of Changing the Independent Variable.

93. Supposing y to be any function of x, we have estimated every change in the magnitude y by that of the value of x, which has been supposed to vary in any way whatever. It is, however, sometimes convenient to reverse the hypothesis, and consider x as a function of y. We are now to investigate general rules, by which we may pass from the differentials of y, regarded as a function of x, to those of x considered as a function of y.

Let $y = f(x)$, and let us suppose that when x becomes $x+h$, y becomes $y+k$. By Taylor's theorem,

$$k = \frac{dy}{dx}h + \frac{d^2y}{dx^2}\frac{h^2}{2} + \frac{d^3y}{dx^3}\frac{h^3}{2.3} + \text{\&c.} \quad \text{(1)}$$

On the reverse hypothesis, supposing $x = \mathrm{F}(y)$ a function of y, then, similarly,

$$h=\frac{dx}{dy}k+\frac{d^2x}{dy^2}\frac{k^2}{2}+\frac{d^3x}{dy^3}\frac{k^3}{2\,.\,3}+\text{\&c.}\ldots\ldots\ldots\ldots(2)$$

Let the value of k, as given by the first equation, be substituted in the second; and, in order to abridge, let us put $\frac{dy}{dx}=y'$, $\frac{d^2y}{dx^2}=y''$, &c.

also $\frac{dx}{dy}=x'$, $\frac{d^2x}{dy^2}=x''$, &c.; then we have

$$h = x'\left(y'h+y''\frac{h^2}{2}+y'''\frac{h^3}{2\,.\,3}+\text{\&c.}\right)$$
$$+\frac{x''}{2}\left(y'h+y''\frac{h^2}{2}+y'''\frac{h^3}{2\,.\,3}+\text{\&c.}\right)^2+\text{\&c.}$$

Hence, by actually involving the series to the second, third, powers, &c. and bringing into one term like powers of h, we find

$$0=(x'y'-1)\,h+(x'y''+x''y'^2)\frac{h^2}{2}$$
$$+(x'y'''+3x''y'y''+x'''y')\frac{h^3}{3}+\text{\&c.}$$

Now, that this equation may be satisfied, the co-efficients of the powers of h must be each $=0$; thus,

$$x'y'-1=0,\quad x'y''+x''y'^2=0,$$
$$x'y'''+3x''y'y''+x'''y'=0,\ \text{\&c.}$$

These equations give us

$$y'=\frac{1}{x'},\quad y''=-\frac{x''}{x'^3},\quad y'''=\frac{3x''^2}{x'^5}-\frac{x'''}{x'^4},$$
$$y^{\mathrm{IV}}=\frac{15x''^3}{x'^7}+\frac{10x''x'''}{x'^6}-\frac{x^{\mathrm{IV}}}{x'^5},\ \text{\&c.}$$

Reversely, we have

$$x'=\frac{1}{y'},\quad x''=-\frac{y''}{y'^3},\quad x'''=\frac{3y''^2}{y'^5}-\frac{y'''}{y'^4},$$
$$x^{\mathrm{IV}}=\frac{15y''^3}{y'^7}+\frac{10y''y'''}{y'^6}-\frac{y^{\mathrm{IV}}}{y'^5},\ \text{\&c.}$$

As an application of these formulæ, we may transform the expression for the radius of curvature found (art. 78), on the hypothesis that y is a function of x, into another in which x is a function of y. Employing the notation of last article,

$$r=-\frac{(1+y'^2)^{\frac{3}{2}}}{y''}.$$

Now by the formulæ $y'=\frac{1}{x'}$, and $y''=-\frac{x''}{x'^3}$: this substitution being made, we obtain

$$r=\frac{(x'^2+1)^{\frac{3}{2}}}{x''}=\frac{(dx^2+dy^2)^{\frac{3}{2}}}{dyd^2x}.$$

94. Instead of supposing that one of the two variables x, y, is a function of the other, it is sometimes convenient to regard both as functions of a third quantity. Thus, in geometry, supposing x and y to be the co-ordinates of a curve, we may consider the one as a function of the other; or we may consider both as functions of the angle which a tangent makes with the axis, which angle is then the independent variable. Or x and y denoting the co-ordinates of the path of a projectile, both may be considered as functions of t, the time of the motion.

Suppose that when t becomes $t+i$, x becomes $x+h$, and that y becomes $y+k$; to abridge, put x', x'', &c. for $\frac{dx}{dt}$, $\frac{d^2x}{dt^2}$, &c.; also y', y'', &c. for $\frac{dy}{dt}$, $\frac{d^2y}{dt^2}$, &c. and (y'), (y''), &c. for $\frac{dy}{dx}$, $\frac{d^2y}{dx^2}$, &c.

By Taylor's theorem,

$$y=f(x)\text{ gives }k=(y')\,h+(y'')\frac{h^2}{2}+\text{\&c.}\ldots\ldots(1)$$
$$y=\mathrm{F}(t)\text{ gives }k=y'i+y''\frac{i^2}{2}+\text{\&c.}\ldots\ldots\ldots\ldots(2)$$
$$x=\varphi(t)\text{ gives }h=x'i+x''\frac{i^2}{2}+\text{\&c.}\ldots\ldots\ldots\ldots(3)$$

The three increments k, h, i are generated together, therefore these equations must all hold true at the same time. Let the value of h, found from the third equation, be substituted in the first, then, putting the two values of k equal, we have

$$(y')\left\{x'i+x''\frac{i^2}{2}+\text{\&c.}\right\}$$
$$+\frac{(y'')}{2}\left\{x'i+x''\frac{i^2}{2}+\text{\&c.}\right\}^2+\text{\&c.}$$
$$=y'i+y''\frac{i^2}{2}+\text{\&c.}$$

Hence, by involution, and making the co-efficients of like powers of i equal to zero, as usual, we find

$$x'(y')=y',\quad x''(y')+x'^2(y'')=y'',\ \text{\&c.}$$

therefore $(y')=\frac{y'}{x'}$ $\qquad (y'')=\frac{y''-x''(y')}{x'^2}$, &c.

As an example, let us take the formula for the radius of curvature, which, by the notation just premised, will be

$$r=-\frac{\{1+(y')^2\}^{\frac{3}{2}}}{(y'')^2}.$$

By substituting for (y') and (y'') their values, it becomes

$$r=-\frac{(x'^2+y'^2)^{\frac{3}{2}}}{x'y''-y'x''};$$

and hence, putting $\frac{dx}{dt}$ for x', $\frac{dy}{dt}$ for y', $\frac{d^2x}{dt^2}$ for x'', and $\frac{d^2y}{dt^2}$ for y'', we get

$$r=\frac{(dx^2+dy^2)^{\frac{3}{2}}}{dyd^2x-dxd^2y}.$$

The independent variable t does not appear in the formula; nevertheless, in its application, we must keep in mind the hypothesis by which it was found.

Of the Method of Infinitesimals.

95. The ideas which we have of infinity may be embodied in this proposition: *A quantity is not infinite so long as it admits of augmentation.* If, therefore, in the quantity $x+a$, we suppose x to become infinite, then a must be suppressed, otherwise it would be supposed that x might be increased by the quantity a, which is contrary to the definition. To show the consistency of the proposition, let there be an equation

$$\frac{1}{a}+\frac{1}{x}=\mathrm{M}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

which being multiplied by the product ax, becomes

$$x+a=\mathrm{M}ax\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Suppose now that x increases until it becomes infinite · the fraction $\frac{1}{x}$, having reached its last degree of diminution, is reduced to 0, and therefore equation (1) becomes

$$\mathrm{M}=\frac{1}{a},\text{ or }\mathrm{M}a=1;$$

Direct Method.

and this value being substituted in equation (2), it becomes $x + a = x$. This shows that when x is infinite, $x + a$ is reduced to x.

The quantity a, in respect of which x is infinite, is called an *infinitesimal* in respect of x.

Since we consider here only the ratios of quantities, the preceding demonstration holds good when x has a finite value, provided that a be infinitely small in respect of x. Thus, if we compare b, a finite quantity, with the fraction $\frac{b}{z}$, then, z being supposed to increase continually, $\frac{b}{z}$ will decrease, and may become smaller than any assignable quantity; and when z is infinite, the fraction is $= 0$, so that, in comparison with b, it may be neglected.

The ratios of quantities are altogether independent of their absolute magnitude. The halves, or any like parts of quantities, have the same ratios as the wholes. The symbols we employ in our reasonings are not the representatives of absolute magnitudes, but of numbers, which have a reference to an unit; they therefore represent ratios only, and the absolute magnitudes of the terms of the ratios are never considered. The differentials of quantities are the ratios to which the ratios of the increments of the variables continually approach; these increments may have any magnitude whatever. Leibnitz supposed them to be infinitely small quantities. Upon this hypothesis a theory has been constructed, which, by following certain ascertained principles, has led to the discovery of the most recondite truths in geometry and physics.

96. The admission of infinitesimals into the mathematical sciences, necessarily leads to a succession of different orders of infinitesimals. In a circle the ratio of the diameter to the chord of an arc is the same as the ratio of the chord to the versed sine; therefore, if the chord be infinitely small in respect of the diameter, or an infinitesimal of the *first* order, the versed sine will be infinitely small in respect of the chord; and, consequently, in respect of the diameter, will be an infinitesimal of the *second* order. So also, in a series of continued proportionals, 1, x, x^2, x^3, &c. of which the first term is finite, and the second, x, an infinitesimal of the first order, the third, x^2, will be of the second order, and the fourth, x^3, of the third, and so on. Upon the same principle, the product ab of two infinitesimals, a, b of the first order will be an infinitesimal of the second; for we may consider that $1 : a = b : ab$, that is, ab is a fourth proportional to three quantities 1, a, and b, of which the first is finite. In like manner, the product of three infinitesimals of the first order, also the product of an infinitesimal of the first and of the second order, will be an infinitesimal of the third order.

97. When the infinitely small increments of quantities are once taken as their differentials, the different rules for differentiation are easily found.

Thus, if $u = xy$; then u, x, and y receiving the infinitely small augments du, dx, and dy, we have

$$u + du = (x + dx)(y + dy) = xy + xdy + ydx + dxdy;$$

and, taking from these equals the equals u and xy,

$$du = xdy + ydx + dxdy.$$

Now du, xdy, ydx are infinitesimals of the first order, and $dxdy$ is an infinitesimal of the second, therefore it is incomparably smaller, and in respect of the others ought to be rejected, so that we have simply

$$du = xdy + ydx.$$

98. In this theory a curve is considered as a polygon of an infinite number of sides, any one of which is the differential of the arc, therefore the differential of the arc will be the hypotenuse of a right-angled triangle, of which the sides are the differentials of the co-ordinates; and these being denoted by x and y, and the arc by z, we have $dz^2 = dx^2 + dy^2$. Proceeding on the same principles, if s denote the area of a curve, the increment of s or ds will be $ydx + \frac{1}{2}dxdy$; but the second part of this, viz. $\frac{1}{2}dxdy$, is a differential of the second order, and therefore infinitely less than ydx, which is of the first order, therefore we have simply $ds = ydx$, agreeing with the formula of art. 69.

Inverse Method.

In a circle, the infinitely small increments of the cosine, the sine, and the arc form a right-angled triangle similar to that formed by the sine, the cosine, and the radius, so that x being put for the arc, the radius being unity,

$1 : \cos x = dx : d \sin x$, $1 : \sin x = dx : -d \cos x$, hence $d \sin x = dx \cos x$, and $d \cos x = -xdx$.

It is equally manifest, according to the infinitesimal theory, that the subtangent is a fourth proportional to dx (the differential of the absciss), dy (the differential of the ordinate), and y the ordinate; so that, as has been shown, art. 65,

$$\text{subtan} = \frac{\pm dy}{dx} y;$$

the positive sign being used if the absciss and ordinate increase together, otherwise the sign $-$.

The great facility which the theory of infinitesimals gives in the applications of the calculus to the higher geometry, and more especially to the doctrines of physics, is a high recommendation in its favour. Indeed, whatever view be taken of the subject, the mathematician will hardly be restrained from taking the shortest way he can find to the object he wishes to attain, and that is in general by the infinitesimal calculus. Accordingly we observe that M. Poisson, in the second edition of his *Traité de Mécanique*, distinctly premises that he will exclusively employ the method of *infiniment petits* throughout his work.

PART II.

INVERSE METHOD OF FLUXIONS, OR INTEGRAL CALCULUS.

99. The *inverse method of fluxions*, or *integral calculus*, treats of the analytic processes by which a function may be found, such, that being differentiated, it shall produce a given differential. This function has been called, by writers on fluxions, the *fluent* or *flowing quantity;* and by writers on the differential calculus, the *integral* of the proposed differential.

To find the integral of a differential is to *integrate* that differential; and the process by which the integral is found is called *integration.*

100. When an integral is proposed, its differential may always be found by general rules. There is however no direct rule by which we may return from the differential to the integral, except the obvious one of retracing the steps by which the differential has been deduced from the integral. When these are distinctly indicated, there is no difficulty; but in general the steps of calculation by which the differential might have been deduced from an integral are obliterated or unknown; or the differential may not have been a direct result of differentiation; and then there will be no traces to show how we may pass from it to the integral.

101. It is convenient to have a symbol by which the integral of a differential may be indicated without regard to its particular form: for this purpose the letter $\int$ (the initial letter of the word *sum*) is employed. Thus, the integral of the differential $\mathrm{X}dx$ is expressed by the symbol $\int \mathrm{X}dx$.

102. We have seen (art. 9) that in differentiating an expression of the form $\mathrm{X} \pm \mathrm{C}$, which is the sum or dif-

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ference of a variable function and a constant quantity, the constant disappears; therefore, reversely, in taking the integral of any differential, the constant, C, must be added to make the integral complete. This indeterminate quantity has been called by early English writers the *correction* of the fluent or integral, but now it is generally called the *arbitrary constant.* It may be written either with the sign $+$ or $-$; its value is to be determined, as will appear hereafter, from the particular problem under consideration.

Integration of Rational Functions involving one Variable.

103. The general form of a differential of the first order of a function is Xdx, where X denotes any function of a single variable x. Now this function may have various forms, and may be rational or irrational.

The rational forms of the function may be

$$Ax^m + Bx^n + Cx^p + \&c. = U,$$

$$\frac{Ax^m + Bx^n + Cx^p + \&c.}{A'x^{m'} + B'x^{n'} + C'x^n + \&c.} = \frac{U}{V},$$

the first of which is integral and the second fractional.

Irrational functions have the form

$$UV^{\frac{m}{n}},$$

and transcendental functions,

$$f(U, \text{l. } U),\ f(U, \sin v),\ \&c.$$

104. The simplest case of a rational function is ax^n, the differential of which is $nax^{n-1}dx$; therefore, putting $m = n - 1$, so that $n = m + 1$, we have,

when $dy = ax^m dx$,

$$\text{then } y = \int ax^m dx = \frac{a}{m+1} x^{m+1} + \text{C}.$$

Hence this rule: *To integrate a differential of one term, such as* $ax^n dx$, *we must increase the exponent of the variable by an unit, and then divide by the new exponent and by* dx.

We may give the indeterminate constant C the form $-\frac{ab^{n+1}}{n+1}$, and then we shall have

$$\int ax^n dx = \frac{a(x^{n+1} - b^{n+1})}{n+1}.$$

This is the form the integral should have, if it has the property of vanishing in the particular case of $x = b$.

105. There is a particular case to which the general rule of last article will not immediately apply; it is that in which $n = -1$; in that case it gives

$$\int \frac{adx}{x} = \int ax^{-1}dx = \frac{a(x^0 - b^0)}{0} = \frac{a(1-1)}{0} = \frac{0}{0}.$$

From this no conclusion can be drawn, and the integral has been said to *fail.* This, however, is only in appearance; for, putting $n+1 = m$, we have (art. 35)

$$x^m = 1 + (\text{l. } x)\, m + (\text{l. } x)^2 \frac{m^2}{1 \cdot 2} + \&c.$$

$$b^m = 1 + (\text{l. } b)\, m + (\text{l. } b)^2 \frac{m^2}{1 \cdot 2} + \&c.$$

$$x^m - b^m = \{\text{l. } x - \text{l. } b\}\, m + \{(\text{l. } x)^2 - (\text{l. } b)^2\} \frac{m^2}{1 \cdot 2} + \&c.$$

$$\frac{x^m - b^m}{m} = \text{l. } x - \text{l. } b + \{(\text{l. } x)^2 - (\text{l. } b)^2 \frac{m}{2} + \&c.$$

This, when $n+1 = m = 0$ and $n = -1$, gives

$$\int \frac{adx}{x} = a\{\text{l. } x - \text{l. } b\} = a \text{ l. } x + \text{C}.$$

This result coincides entirely with the expression for the differential of the logarithm of a number (art. 20).

106. By the rule of art. 104 it is evident that if

$$dy = ax^m dx + bx^n dx + cx^p dx,$$

$$\text{then, } y = \frac{ax^{m+1}}{m+1} + \frac{bx^{n+1}}{n+1} + \frac{cx^{p+1}}{p+1} + \text{C}.$$

This is true, however many terms there may be in the differential: the indeterminate constant C represents the aggregate of all the constants of the integrals of the several terms.

In general, since (art. 15),

$$d(u + v - z) = du + dv - dz,$$

$$\text{therefore } u + v - z = \int du + \int dv - \int dz;$$

and in general, P, Q, R, being any functions of x,

$$\int (\text{P}dx + \text{Q}dx - \text{R}dx) = \int \text{P}dx + \int \text{Q}dx - \int \text{R}dx.$$

107. It has been found that u and v being any functions of a variable, $d(uv) = udv + vdu$, therefore

$$\int udv = uv - \int vdu.$$

In like manner, from the differential of a fraction we find

$$\int u \frac{dv}{v^2} = -\frac{u}{v} + \int \frac{du}{v}.$$

Since $d(au) = adu$, we may conclude that

$$\int a\text{X}dx = a \int \text{X}dx.$$

108. To integrate the differential

$$dy = (ax + b)^m dx,$$

we may expand the given power, and integrate the terms of the result separately; otherwise, make $z = ax + b$, then

$$x = \frac{z - b}{a},\ dx = \frac{dz}{a}.$$

By substitution, we have now $dy = \frac{z^m dz}{a}$, and by integration,

$$y = \frac{z^{m+1}}{a(m+1)} + \text{C} = \frac{(ax + b)^{m+1}}{a(m+1)} + \text{C}.$$

The integral of $dy = (ax^n + b)^m x^{n-1} dx$ may be found in the same way, by putting $ax^n + b = z$; we thus get

$$y = \frac{(ax^n + b)^{m+1}}{na(m+1)} + \text{C}.$$

109. We shall next consider fractional functions, and begin with the simple case of $dy = \frac{\text{A}x^m dx}{(ax + b)^n}$; making $z = ax + b$, we find

$$x = \frac{z - b}{a},\ dx = \frac{dz}{a},$$

and consequently

$$dy = \frac{\text{A}(z - b)^m dz}{a^{m+1} z^n}.$$

By expanding $(z - b)^m$ into a series, then multiplying the terms by dz, and dividing by z^n, the differential will be transformed into a series of terms of the form $cz^p dz$, which

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may be integrated severally by the rule (art 104). As a particular example, let $m=3$, $n=2$, then

$$dy=\frac{A(z-b)^3dz}{a^4z^2}$$

$$=\frac{A}{a^4}\left\{zdz-3bdz+3b^2z^{-1}dz-b^3z^{-2}dz\right\}:$$

Hence, integrating by the rule,

$$y=\frac{A}{a^4}\left\{\frac{z^2}{2}-3bz+3b^2\,\mathrm{l}.z+b^3z^{-1}\right\}+C.$$

We now substitute for z its value, and find

$$y=\frac{A}{a^4}\left\{\begin{matrix}\frac{1}{2}(ax+b)^2-3b(ax+b)\\ +3b^2\,\mathrm{l}.(ax+b)+\dfrac{b^3}{ax+b}\end{matrix}\right\}+C.$$

110. All differentials which are rational fractions may be reduced to this form,

$$\frac{(Ax^{n-1}+Bx^{n-2}+Cx^{n-3}\ldots+T)dx}{x^n+A'x^{n-1}+B'x^{n-2}\ldots+T'}.$$

The general method of integrating such a differential consists in decomposing it into others whose denominators are more simple, which are called *partial fractions.* These are obtained as follows.

Assume the denominator of the proposed fraction equal to *zero*, thus forming the equation

$$x^n+A'x^{n-1}+B'x^{n-2}\ldots\ldots+T'=0.$$

Let the roots of this equation be

$$x=-a,\ x=-a',\ x=-a'',\ x=-a''',\ \&c.$$

and supposing them all different, the first side of the equation will be (ALGEBRA, art. 99) the product of n factors,

$$x+a,\ x+a',\ x+a'',\ x+a''',\ \&c.$$

We now assume that the proposed fraction is the sum of the fractions

$$\frac{Ndx}{x+a},\ \frac{N'dx}{x+a'},\ \frac{N''dx}{x+a''},\ \&c.$$

of which the denominators are the factors of the proposed fraction, and the numerators are undetermined constants. These being reduced to a common denominator, and added, the result will be a fraction identical with the proposed fraction; and by putting the co-efficients of like powers of x in their numerators equal to one another, a series of equations will be had, by which the undetermined constants N, N′, N″, &c. may be found.

As an example, suppose the differential to be integrated is

$$\frac{(Ax^2+Bx+C)\,dx}{x^3+A'x^2+B'x+C'},$$

and that by the resolution of an equation we know that

$$x^3+A'x^2+B'x+C'=(x+a)(x+a')(x+a'').$$

setting aside dx, we assume that the fraction is equivalent to

$$\frac{N}{x+a}+\frac{N'}{x+a'}+\frac{N''}{x+a''}.$$

The sum of these is

$$\frac{N(x+a')(x+a'')+N'(x+a)(x+a'')+N''(x+a)(x+a')}{(x+a)(x+a')(x+a'')}.$$

The numerator of this fraction is, by multiplying its factors,

$$(N+N'+N'')x^2+\{N(a'+a'')+N'(a+a'')+N''(a+a')\}x$$
$$+Na'a''+N'aa''+N''aa';$$

and as this must be equal to the numerator of the proposed differential, whatever be the value of x, the co-efficients of like powers of x will be equal (art. 18); hence we have these three equations,

$$N+N'+N''=A.$$
$$N(a'+a'')+N'(a+a'')+N''(a+a')=B,$$
$$Na'a''+N'aa''+N''aa'=C;$$

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which are only of the first degree with respect to the undetermined quantities N, N′, N″. Resolving these equations, we find N, N′, N″, and have

$$\frac{(Ax^2+Bx+C)dx}{x^3+A'x^2+B'x+C'}$$
$$=\frac{Ndx}{x+a}+\frac{N'dx}{x+a'}+\frac{N''dx}{x+a''}.$$

Making $x+a=z$, we have $dx=dz$, and $\frac{Ndx}{x+a}=\frac{Ndz}{z}$, the integral of which is $N\,\mathrm{l}.z=N\,\mathrm{l}.(x+a)$; similarly,

$$\int\frac{N'dx}{x+a'}=N'\,\mathrm{l}.(x+a');\int\frac{N''dx}{x+a'}=N''\,\mathrm{l}.(x+a'').$$

So that we have now

$$\int\frac{(Ax^2+Bx+C)dx}{x^3+A'x^2+B'x+C'}$$
$$=N\,\mathrm{l}.(x+a)+N'\mathrm{l}.(x+a')+N''\mathrm{l}.(x+a'')+\text{const.}$$
$$=\mathrm{l}.\left\{(x+a)^{N}\cdot(x+a')^{N'}\cdot(x+a'')^{N''}\right\}+\text{const.}$$

This process, which may be extended to all rational fractions whose denominators are decomposable into unequal factors of the *first* degree, has no difficulty, independent of the decomposition of the denominator into its factors, which, however, requires the numerical resolution of equations.

111. If some of the factors of the denominator of the proposed fraction are equal, the process will require to be modified to suit that case. Suppose the denominator $x^n+A'x^{n-1}+$, &c.... $+T'$ to contain a factor $(x+a)^p$, then, for every such factor, it will be necessary to assume a partial fraction of the form

$$\frac{(Px^{p-1}+Qx^{p-2}+,\ \&c.\ldots+Y)dx}{(x+a)^p}.$$

This and the other partial fractions being reduced to a common denominator, and added, and the terms of the numerator in the result being put equal to those of the numerator of the proposed differential, as before, as many independent equations will be obtained as there are co-efficients to be determined.

112. It is not difficult to see that the partial fraction suited to the case of equal factors may be transformed into an expression of the form

$$\frac{Ndx}{(x+a)^p}+\frac{N'dx}{(x+a)^{p-1}}\cdots+\frac{N''dx}{x+a};$$

therefore we may at once substitute this instead of the equivalent single fraction. We shall now have to integrate a series of differentials of the form

$$\frac{Ndx}{(x+a)^p},$$

which, by making $x+a=z$, and therefore $dx=dz$, gives

$$\int\frac{Ndx}{(x+a)^p}=\int\frac{Ndz}{z^p}=\frac{Nz^{-p+1}}{1-p}$$
$$=\frac{N}{(1-p)(x+a)^{p-1}}.$$

These will be all algebraical except the last, $\int\frac{Ndx}{x+a}$, which will involve a logarithm.

113. If there be imaginary factors, these will occur in pairs of the form $x+\alpha+\beta\sqrt{-1}$, $x+\alpha-\beta\sqrt{-1}$,

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and their product will be $x^2+2\alpha x+\alpha^2+\beta^2$. In this case the best way to proceed will be to resolve the denominator of the proposed differential into real factors of the first and of the second degree, which is always possible (see EQUATIONS). If there be several pairs of these imaginary factors, each pair the same, the denominator of the proposed differential will have factors of the form $(x^2+2\alpha x+\alpha^2+\beta^2)^q$. Then, for the single factor $x^2+2\alpha x+\alpha^2+\beta^2$, we must assume, in addition to the partial fractions, for factors of the first degree, one of this form,

$$\frac{(\mathrm{K}x+\mathrm{L})dx}{x^2+2\alpha x+\alpha^2+\beta^2};$$

and for factors of the second form, this fraction,

$$\frac{(\mathrm{Q}x^{2q-1}+\mathrm{R}x^{2q-2}\ldots+\mathrm{Y}')\,dx}{(x^2+2\alpha x+\alpha^2+\beta^2)^q};$$

or, instead of this, a series of fractions,

$$\frac{(\mathrm{K}x+\mathrm{L})\,dx}{(x^2+2\alpha x+\alpha^2+\beta^2)^q}+\frac{(\mathrm{K}'x+\mathrm{L}')dx}{(x^2+2\alpha x+\alpha^2+\beta^2)^{q-1}}$$

$$\ldots\ldots\ldots\ldots\ldots\ldots+\frac{(\mathrm{K}'''x+\mathrm{L}''')dx}{x^2+2\alpha x+\alpha^2+\beta^2};$$

the co-efficients to be determined, as before explained.

114. To integrate the fraction

$$\frac{(\mathrm{K}x+\mathrm{L})\,dx}{x^2+2\alpha x+\alpha^2+\beta^2},$$

we observe that $x^2+2\alpha x+\alpha^2+\beta^2=(x+\alpha)^2+\beta^2$; and if we make $x+\alpha=z$, then

$$\frac{(\mathrm{K}x+\mathrm{L})dx}{(x+\alpha)^2+\beta^2}=\frac{(\mathrm{K}z+\mathrm{L}-\mathrm{K}\alpha)dz}{z^2+\beta^2}$$

$$=\frac{\mathrm{K}zdz}{z^2+\beta^2}+\frac{\mathrm{L}'dz}{z^2+\beta^2}.$$

Here L' is put for the constant quantity $\mathrm{L}-\mathrm{K}\alpha$. Now, the integral of the first of these differentials may be expressed by a logarithm; for, making $z^2+\beta^2=u$, we have $zdz=\frac{1}{2}du$, which gives

$$\int\frac{\mathrm{K}zdz}{z^2+\beta^2}=\frac{\mathrm{K}}{2}\int\frac{du}{u}=\mathrm{K}\tfrac{1}{2}\,\mathrm{l}.\,u=\mathrm{K}\,\mathrm{l}.\sqrt{z^2+\beta^2}.$$

With respect to the second part, we make $z=\beta v$, then,

$$\frac{\mathrm{L}'dz}{z^2+\beta^2}=\frac{\mathrm{L}'}{\beta}\,\frac{dv}{v^2+1}.$$

But we have found (art. 23) that $\frac{dv}{v^2+1}$ is the differential of the arc whose tangent is v, which is expressed by $\tan^{-1}v$, therefore

$$\int\frac{\mathrm{L}'}{\beta}\cdot\frac{dv}{v^2+1}=\frac{\mathrm{L}'}{\beta}\tan^{-1}v+\text{const.}$$

$$=\frac{\mathrm{L}'}{\beta}\tan^{-1}\frac{z}{\beta}+\text{const.}$$

Adding now these results, we get

$$\int\frac{(\mathrm{K}z+\mathrm{L}')dz}{z^2+\beta^2}=\mathrm{K}\,\mathrm{l}.\sqrt{z^2+\beta^2}+\frac{\mathrm{L}'}{\beta}\tan^{-1}\frac{z}{\beta}+\text{const.}$$

When the value of z and L' are replaced, we have

$$\int\frac{(\mathrm{K}x+\mathrm{L})dx}{x^2+2\alpha x+\alpha^2+\beta^2}=\text{const.}$$

$$+\mathrm{K}\,\mathrm{l}.\sqrt{x^2+2\alpha x+\alpha^2+\beta^2}+\frac{\mathrm{L}-\mathrm{K}\alpha}{\beta}\tan^{-1}\frac{x+\alpha}{\beta}.$$

115. To integrate the differential

$$\frac{(\mathrm{K}x+\mathrm{L})dx}{(x^2+2\alpha x+\alpha^2+\beta^2)^q},$$

we shall at once make $x+\alpha=z$, and $\mathrm{L}-\mathrm{K}\alpha=\mathrm{L}'$. By this the differential is transformed to

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$$\frac{(\mathrm{K}z+\mathrm{L}')dz}{(z^2+\beta^2)^q}=\frac{\mathrm{K}zdz}{(z^2+\beta^2)^q}+\frac{\mathrm{L}'dz}{(z^2+\beta^2)^q}.$$

To transform the first part, we make $z^2+\beta^2=u$, so that $zdz=\frac{du}{2}$, and consequently,

$$\int\frac{\mathrm{K}zdz}{(z^2+\beta^2)^q}=\frac{\mathrm{K}}{2}\int\frac{du}{u^q}=\frac{\mathrm{K}}{2}\cdot\frac{u^{-q+1}}{1-q}.$$

To integrate the second part, we assume the equation

$$\int\frac{dz}{(z^2+\beta^2)^q}=\frac{\mathrm{G}z}{(z^2+\beta^2)^{q-1}}+\mathrm{H}\int\frac{dz}{(z^2+\beta^2)^{q-1}};$$

that is, we assume the integral to be equal to an algebraic quantity, together with another integral whose denominator is less by an unit than the first. We now differentiate the terms of the assumed equation, observing that the removal of $\int$, the sign of an integral, is equivalent to the differentiation of that integral; we also reject such factors as are common to all the terms of the result, and thus have

$$1=\mathrm{G}\,(z^2+\beta^2)-2\,(q-1)\,\mathrm{G}z^2+\mathrm{H}\,(z^2+\beta^2);$$

$$\text{and }\{(3-2q)\,\mathrm{G}+\mathrm{H}\}\,z^2+(\mathrm{G}+\mathrm{H})\,\beta^2-1=0.$$

Now, that z may remain undetermined, we must have

$$(\mathrm{G}+\mathrm{H})\,\beta^2-1=0,\quad(3-2q)\,\mathrm{G}+\mathrm{H}=0.$$

From these equations, we find

$$\mathrm{G}=\frac{1}{(2q-2)\beta^2},\qquad\mathrm{H}=\frac{2q-3}{(2q-2)\beta^2}.$$

The values of G and H being substituted in our assumed equation, it becomes

$$\int\frac{dz}{(z^2+\beta^2)^q}=\frac{1}{(2q-2)\beta^2}\;\frac{z}{(z^2+\beta^2)^{q-1}},$$

$$+\frac{2q-3}{(2q-2)\beta^2}\int\frac{dz}{(z^2+\beta^2)^{q-1}}.$$

This formula gives the means of depressing the index of the denominator of the proposed fraction; for, putting $q-1$ instead of q, we find

$$\int\frac{dz}{(z^2+\beta^2)^{q-1}}=\frac{1}{(2q-4)\beta^2}\;\frac{z}{(z^2+\beta^2)^{q-2}},$$

$$+\frac{2q-5}{(2q-4)\beta^2}\int\frac{dz}{(z^2+\beta^2)^{q-2}};$$

and again, putting $q-2$ for q, we get

$$\int\frac{dz}{(z^2+\beta^2)^{q-2}}=\frac{1}{(2q-6)\beta^2}\;\frac{z}{(z^2+\beta^2)^{q-3}},$$

$$+\frac{2q-7}{(2q-6)\beta^2}\int\frac{dz}{(z^2+\beta^2)^{q-3}}.$$

In this way the integral $\int\frac{dz}{(z^2+\beta^2)^q}$ is expressed by an algebraic quantity, and another integral, $\int\frac{dz}{(z^2+\beta^2)^{q-1}}$; and this last by another algebraic quantity, and the integral $\int\frac{dz}{(z^2+\beta^2)^{q-2}}$; and so on, until we come to the integral $\int\frac{dz}{z^2+\beta^2}$, which is known, and expressible by the arc of a circle. Here the process must stop; for the next transformation would involve the integral $\int\frac{dz}{(z^2+\beta^2)^0}$, with

an infinite co-efficient, from which no conclusion can be drawn. Here we see the application of a method of integration at once fertile and elegant.

From what has been explained, it appears that differentials which are rational fractions may be always integrated either algebraically or by means of logarithms or circular arcs; all that is necessary is to decompose them into partial fractions, whose denominators are either binomial or trinomial quantities.

116. We shall now give some examples of the integration of differentials which are rational fractions.

1. Let the differential be $\frac{adx}{x^2-a^2}$.

In this case the denominator $x^2-a^2=(x-a)(x+a)$; we therefore assume

$$\frac{adx}{(x-a)(x+a)}=\left\{\frac{A}{x-a}+\frac{B}{x+a}\right\}dx.$$

We now reduce the second side to a single fraction, and, leaving out dx, have

$$\frac{a}{(x-a)(x+a)}=\frac{(A+B)x+(A-B)a}{(x-a)(x+a)};$$

therefore $a=(A+B)x+(A-B)a$.

Now, x being indeterminate, according to the principle of art. 18, we must have

$$(A-B)a=a,\quad A+B=0;$$

these equations give $A=\frac{1}{2}$, $B=-\frac{1}{2}$; the proposed differential is now

$$\frac{adx}{x^2-a^2}=\tfrac{1}{2}\frac{dx}{x-a}-\tfrac{1}{2}\frac{dx}{x+a};$$

and, by integrating,

$$\int\frac{adx}{x^2-a^2}=\tfrac{1}{2}\,\mathrm{l.}(x-a)-\tfrac{1}{2}\,\mathrm{l.}(x+a)+C,$$

$$=\tfrac{1}{2}\,\mathrm{l.}\frac{x-a}{x+a}+C=\mathrm{l.}\sqrt{\frac{x-a}{x+a}}+C.$$

2. Let the differential be $\frac{a^3+b^2x^2}{a^2x-x^3}dx$.

The factors of the denominator are x and a^2-x^2, which last resolves into $(a-x)(a+x)$; therefore, leaving out dx, we assume

$$\frac{a^3+bx^2}{x(a-x)(a+x)}=\frac{A}{x}+\frac{B}{a-x}+\frac{C}{a+x}.$$

The second side of this equation, by reducing its terms to a common denominator, and adding, is

$$\frac{Aa^2+a(B+C)x+(B-A-C)x^2}{x(a-x)(a+x)}.$$

By equating the co-efficients of the powers of x, we have

$$Aa^2=a^3,\quad a(B+C)=0,\quad B-A-C=b.$$

Here there are three unknown quantities, viz. A, B, C, and three simple equations, therefore they may be found, as taught in ALGEBRA, sect. viii.; and accordingly we have

$$A=a,\quad B=\tfrac{1}{2}(a+b),\quad C=-\tfrac{1}{2}(a+b),$$

$$\frac{a^3+bx^2}{a^2x-x^3}dx=\frac{adx}{x}+\frac{a+b}{2(a-x)}dx-\frac{a+b}{2(a+x)}dx;$$

and, integrating,

$$\int\frac{a^3+bx^2}{a^2x-x^3}dx=a\,\mathrm{l.}x-\frac{a+b}{2}\,\mathrm{l.}(a-x)$$

$$-\frac{a+b}{2}\,\mathrm{l.}(a+x)+C.$$

By the nature of logarithms $\mathrm{l.}P+\mathrm{l.}Q=\mathrm{l.}(PQ)$ and $n\,\mathrm{l.}P=\mathrm{l.}P^n$; hence the integral may be otherwise expressed thus,

$$\int\frac{a^3+bx^2}{a^2x-x^3}dx=\mathrm{l.}\frac{x^a}{(a^2-x^2)^{\frac{1}{2}(a+b)}}+C.$$

3. Let the differential be $\frac{3x-5}{x^2-6x+8}dx$.

To resolve the denominator into simple factors, we make $x^2-6x+8=0$, and find the roots of this equation to be $x=2$, and $x=4$; therefore, $x^2-6x+8=(x-2)(x-4)$. To decompose the fraction, leaving out dx, we now assume

$$\frac{3x-5}{(x-2)(x-4)}=\frac{A}{x-2}+\frac{B}{x-4},$$

$$=\frac{(A+B)x-4A-2B}{(x-2)(x-4)}.$$

Hence, equating the like terms in the numerators, we have

$$A+B=3,\quad -4A-2B=-5.$$

From these equations we find $A=-\frac{1}{2}$, $B=\frac{7}{2}$, and

$$\int\frac{(3x-5)dx}{x^2-6x+8}=-\tfrac{1}{2}\int\frac{dx}{x-2}+\frac{7}{2}\int\frac{dx}{x-4},$$

$$=\frac{7}{2}\,\mathrm{l.}(x-4)-\tfrac{1}{2}\,\mathrm{l.}(x-2)+C.$$

4. As an example of equal simple factors in the denominator, let the differential be

$$\frac{x^2dx}{(x^2-a^2)(x-a)}=\frac{x^2dx}{(x-a)^2(x+a)}.$$

In this case we assume (art. 112),

$$\frac{x^2}{(x-a)^2(x+a)}=\frac{A}{(x-a)^2}+\frac{B}{x-a}+\frac{C}{x+a}$$

$$=\frac{A(x+a)+B(x^2-a^2)+C(x-a)^2}{(x-a)^2(x+a)}$$

$$=\frac{Aa-Ba^2+Ca^2+(A-2aC)x+(B+C)x^2}{(x-a)^2(x+a)}.$$

By equating like terms of the numerators, we have

$$Aa-Ba^2+Ca^2=0,\quad A-2aC=0,\quad B+C=1.$$

Hence, by the ordinary process for resolving simple equations involving three unknown quantities, we find

$$A=\tfrac{1}{2}a,\quad B=\tfrac{3}{4},\quad C=\tfrac{1}{4},$$

and the transformed differential is

$$\frac{x^2dx}{(x-a)^2(x+a)}=\frac{a}{2}\frac{dx}{(x-a)^2}+\tfrac{3}{4}\frac{dx}{x-a}+\tfrac{1}{4}\frac{dx}{x+a}.$$

By integration we have

$$\int\frac{dx}{(x-a)^2}=\frac{-1}{x-a},\ \int\frac{dx}{x-a}=\mathrm{l.}(x-a),\ \int\frac{dx}{x+a}=\mathrm{l.}(x+a);$$

therefore, supplying the co-efficients of the partial fractions, and, as usual, an indeterminate constant, we have

$$\int\frac{x^2dx}{(x^2-a^2)(x-a)}=-\frac{a}{2}\frac{1}{x-a}+\tfrac{3}{4}\,\mathrm{l.}(x-a)$$

$$+\tfrac{1}{4}\,\mathrm{l.}(x+a)+\mathit{const.}$$

5. Let the differential be $\frac{x^3+x^2+2}{x(x+1)^2(x-1)^2}dx$.

The denominator contains two pairs of equal factors; we therefore assume (art. 112) $\frac{x^3+x^2+2}{x(x+1)^2(x-1)^2}$ equal to

$$\frac{A}{x}+\frac{B}{(x+1)^2}+\frac{C}{(x+1)}+\frac{D}{(x-1)^2}+\frac{E}{x-1}.$$

By proceeding as in the foregoing examples, uniting the partial fractions into one fraction, and equating the co-efficients of like powers of x, we find

$$A=2,\ B=-\tfrac{1}{2},\ C=-\tfrac{5}{4},\ D=1,\ E=-\tfrac{3}{4}.$$

The proposed differential is now decomposed into these,

$$\frac{2dx}{x} - \frac{1}{2}\frac{dx}{(x+1)^2} - \frac{5}{4}\frac{dx}{x+1} + \frac{dx}{(x-1)^2} - \frac{3}{4}\frac{dx}{x-1}.$$

Hence, by integration,

$$\int \frac{x^3+x^2+2}{x(x+1)^2(x-1)^2}dx = 2\,\mathrm{l}.\,x + \frac{1}{2}\frac{1}{x+1} - \frac{5}{4}\mathrm{l}.\,(x+1)$$
$$-\frac{1}{x-1} - \frac{3}{4}\mathrm{l}.\,(x-1) + \text{const.}$$

6. As an example of a fraction, in which one of the factors in the denominator is a function of the second degree, which does not admit of resolution into real factors of the first degree, let the differential to be integrated be $\frac{a+bx}{x^3-1}dx.$

The denominator $x^3 - 1 = (x-1)(x^2+x+1)$. The expression $x^2 + x + 1$ is of that kind which cannot be resolved into real factors, although it may into two imaginary factors. For, making $x^2 + x + 1 = 0$, and resolving this quadratic equation, we find $x = \frac{-1 \pm \sqrt{-3}}{2}$, and $x^2 + x + 1 = (x + \frac{1}{2} + \frac{1}{2}\sqrt{-3})(x + \frac{1}{2} - \frac{1}{2}\sqrt{-3})$.

To avoid impossible quantities, we assume (art. 113),

$$\frac{a+bx}{(x-1)(x^2+x-1)} = \frac{A}{x-1} + \frac{Bx+C}{x^2+x-1}.$$

Reducing now the partial fractions to a common denominator, and comparing the co-efficients of like powers, we find

$A = \frac{1}{3}(a+b)$, $B = -\frac{1}{3}(a+b)$, $C - \frac{1}{3}(2a-b)$.

The proposed differential and its equivalent transformed expression will therefore be

$$\frac{a+bx}{(x-1)(x^2+x+1)}dx = \frac{a+b}{3}\cdot\frac{dx}{x-1}$$
$$-\frac{1}{3}\frac{(a+b)x+2a-b}{x^2+x+1}dx.$$

The first integral of these differentials is expressible by a logarithm; to transform the second, we put $x^2 + x + 1$ under the form $(x+\frac{1}{2})^2 + \frac{3}{4}$, and make $x + \frac{1}{2} = z$; then, $x = z - \frac{1}{2}$, $dx = dz$, $(a+b)x + 2a - b = (a+b)z + \frac{3}{2}(a-b)$, and

$$\frac{1}{3}\frac{(a+b)x+2a-b}{x^2+x+1}dx = \frac{a+b}{3}\frac{zdz}{z^2+\frac{3}{4}}$$
$$+\frac{a-b}{2}\frac{dz}{z^2+\frac{3}{4}}.$$

The first of these two is also expressible by a logarithm. To simplify the second, we make $z^2 = \frac{3}{4}v^2$; so that $dz = \frac{\sqrt{3}}{2}dv$, and $\frac{dz}{z^2+\frac{3}{4}} = \frac{2}{\sqrt{3}}\frac{dv}{1+v^2}$. On the whole, the differential prepared for integration by known rules is

$$\frac{(a+bx)dx}{x^3-1} = \frac{a+b}{3}\frac{dx}{x-1} - \frac{a+b}{3}\frac{zdz}{z^2+\frac{3}{4}}$$
$$-\frac{a-b}{\sqrt{3}}\frac{dv}{1+v^2};$$

and, integrating,

$$\int\frac{(a+bx)dx}{x^3-1} = \frac{a+b}{3}\mathrm{l}.\,(x-1) - \frac{a+b}{6}\mathrm{l}.\,(z^2+\tfrac{3}{4})$$
$$-\frac{a-b}{\sqrt{3}}\tan^{-1}v + \text{const.};$$

this integral, by putting for z and v their values in terms of x, will also be

$$\int\frac{(a+bx)dx}{x^3-1} = \frac{a+b}{3}\mathrm{l}.\,\frac{x-1}{\sqrt{x^2+x+1}}$$
$$-\frac{a-b}{\sqrt{3}}\tan^{-1}\left\{\frac{2x+1}{\sqrt{3}}\right\} + \text{const.}$$

117. The method of resolving a rational fraction into its component partial fractions, by the theory of indeterminate co-efficients (art. 110–113), is the most elementary of any; it is however tedious. We shall therefore now show how the labour may be abridged.

Let $\frac{U}{V}$ be a rational fraction in its lowest terms, the denominator of which has unequal divisors of the first degree; let $x + a$ be one of them, and Q the product of all the other factors, whether of the first or second degree; so that

$$V = (x+a)Q.$$

In this case we assume

$$\frac{U}{V} = \frac{A}{x+a} + \frac{P}{Q},$$

where A is independent of x, and P and Q are functions of x, the latter being supposed known. By reducing to a common denominator, and remembering that $V = (x+a)Q$, we have the identical equation

$$U = AQ + P(x+a),$$

in which, by hypothesis, neither U nor Q are divisible by $x + a$. Let us make $x + a = 0$, that is, $x = -a$, and upon that hypothesis let u and q denote the values of U and Q respectively; then the equation becomes $u = Aq$, and hence $A = \frac{u}{q}$. This determines the numerator of the partial fraction $\frac{A}{x+a}$, and in the same way may the numerators of all the partial fractions be found.

As an example, let the fraction to be resolved be

$$\frac{U}{V} = \frac{mx+n}{(x+a)(x-b)} = \frac{A}{x+a} + \frac{B}{x-b};$$

$$\text{then, } \frac{mx+n}{x-b} = A + \frac{B}{x-b}(x+a),$$

$$\text{and } \frac{mx+n}{x+a} = B + \frac{A}{x+a}(x-b).$$

Making $x = -a$, the first of these gives

$$A = \frac{-ma+n}{-a-b} = \frac{ma-n}{a+b};$$

and making $x = +b$, the second gives $B = \frac{mb+n}{a+b}$.

Hence we have

$$\frac{mx+n}{(x+a)(x-b)} = \frac{1}{a+b}\left\{\frac{ma-n}{x+a} + \frac{mb+n}{x-b}\right\}.$$

118. The differential calculus may be applied to the determination of the constants A, B, &c. Resuming the equation $V = (x+a)Q$, we have, by differentiation, $\frac{dV}{dx} = Q + \frac{dQ}{dx}(x+a)$. Suppose that when $x = -a$, then $\frac{dV}{dx}$ becomes v', and, as before, that Q becomes q, the differential equation will now become $v' = q$; and since $A = \frac{u}{q}$, therefore also $A = \frac{u}{v'}$.

In the preceding example, in which $V = (x+a)(x-b)$, we have

$$\frac{dV}{dx} = 2x + a - b.$$

The supposition that $x = -a$ makes $\frac{dV}{dx} = -a - b = v'$, and the supposition that $x = +b$ makes $\frac{dV}{dx} = a + b = v'$; these values of $v' = q$ give the values of A and B, the same as before.

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119. Let us now suppose, that in the fraction $\frac{U}{V}$, the denominator $V = (x + a)^n Q$, that is, the product of n equal factors, and Q, the product of all the remaining factors; so that the assumption is $\frac{U}{V} = \frac{U}{Q(x+a)^n} =$

$$\frac{A}{(x+a)^n} + \frac{B}{(x+a)^{n-1}} + \frac{C}{(x+a)^{n-2}} \ldots + \frac{E}{x+a} + \frac{P}{Q},$$

where A, B, C, ...E are constant quantities, and P, Q functions of x. In this case, multiplying all the terms by $(x+a)^n$, we have

$$\frac{U}{Q} = A + B(x+a) + C(x+a)^2 \ldots$$
$$+ E(x+a)^{n-1} + \frac{P}{Q}(x+a)^n.$$

The supposition that $x = -a$ gives to U and Q particular values, which, as before, we denote by u and q; the terms which contain $x + a$ all vanish, and we have $A = \frac{u}{q}$; thus A is known.

Since $\frac{U - AQ}{Q} = B(x+a) + C(x+a)^2 + \&c.$ the numerator, $U - AQ$, of the first side of the equation must necessarily be divisible by $x + a$, and may be expressed by $U_1 (x + a)$. We have now

$$\frac{U_1}{Q} = B + C(x+a) \ldots + E(x+a)^{n-2} + \frac{P}{Q}(x+a)^{n-1}.$$

The quantity U_1 not being divisible by $x + a$, the assumption that $x = -a$ will give it a particular value, which we shall denote by u_1. This assumption will give Q the same particular value as before; the terms which contain $(x + a)$ as a factor will all vanish, and we shall have $B = \frac{u_1}{q}$. In this way may all the remaining numerators C, &c. to E be found.

As a particular example of this process, let the fraction $\frac{U}{V}$ be $\frac{x^2}{(1-x)^3(1+x^2)}$. We assume

$$\frac{x^2}{(1+x^2)(1-x)^3} = \frac{A}{(1-x)^3} + \frac{B}{(1-x)^2} + \frac{C}{1-x} + \frac{P}{1+x^2};$$

hence, multiplying by $(1-x)^3$, we have

$$\frac{x^2}{1+x^2} = A + B(1-x) + C(1-x)^2 + \frac{P}{1+x^2}(1-x)^3.$$

Making $1 - x = 0$, or $x = 1$, we have $A = \frac{1}{2}$, and $\frac{x^2}{1+x^2}$

$$-A = -\frac{1+x}{2(1+x^2)}(1-x) = B(1-x) + C(1-x)^2 + \frac{P}{1+x^2}(1-x)^3,$$

and $-\frac{1+x}{2(1+x^2)} = B + C(1-x) + \frac{P}{1+x^2}(1-x)^2$;

again, making $x = 1$, we find $B = -\frac{1}{2}$, and

$$-\frac{1+x}{2(1+x^2)} - B = \frac{-x}{2(1+x^2)}(1-x) = C(1-x) + \frac{P}{1+x^2}(1-x)^2;$$

and $\frac{-x}{2(1+x^2)} = C + \frac{P}{1+x^2}(1-x)$.

Lastly, making $x = 1$, we have $C = -\frac{1}{4}$, and the fraction

$$\frac{x^2}{(1+x^2)(1-x)^3} = \frac{1}{2}\frac{1}{(1-x)^3} - \frac{1}{2}\frac{1}{(1-x)^2} - \frac{1}{4}\frac{1}{1-x} + \frac{P}{1+x^2}.$$

120. In this case we may also find the numerators A, B, C, &c. by the differential calculus. From the equation of art. 119 we have

$$U = Q\begin{cases} A + B(x+a) + C(x+a)^2 \ldots \\ + E(x+a)^{n-1} + P(x+a)^n. \end{cases}$$

If we now differentiate this equation $(n-1)$ times in succession, and then make $x + a = 0$, both in this equation and those which we deduce from it, there will arise

$$U = AQ,$$
$$\frac{dU}{dx} = A\frac{dQ}{dx} + BQ,$$
$$\frac{d^2U}{dx^2} = A\frac{d^2Q}{dx^2} + 2B\frac{dQ}{dx} + 2CQ,$$
$$\frac{d^3U}{dx^3} = A\frac{d^3Q}{dx^3} + 3B\frac{d^2Q}{dx^2} + 6C\frac{dQ}{dx} + 6DQ,$$
&c.

equations which determine each of the unknown quantities A, B, C, &c. by means of those which precede it, it being well understood that we substitute after each differentiation $-a$ in the place of x in the differential co-efficients. In this case the most simple way of determining Q will be to divide V by $(x-a)^n$. But it may also be found by differentiation, as in art. 118.

121. Let us now suppose that $\frac{U}{V}$, the fraction to be decomposed, has a factor of the second degree, viz. $x^2 + 2\alpha x + \alpha^2 + \beta^2$, which cannot be resolved into two real factors of the first degree.

In this case, $V = (x^2 + 2\alpha x + \alpha^2 + \beta^2)Q$, and we assume

$$\frac{U}{V} = \frac{Ax + B}{x^2 + 2\alpha x + \alpha^2 + \beta^2} + \frac{P}{Q}.$$

Then, $U = (Ax + B)Q + P(x^2 + 2\alpha x + \alpha^2 + \beta^2)$.

If we substitute for x one of the imaginary roots of the equation $x^2 + 2\alpha x + \alpha^2 + \beta^2 = 0$, the term containing P will disappear, and the result will contain two kinds of terms; one real, and the other imaginary. We must now put the real quantities equal to each other, and also the imaginary quantities; thus two equations will be obtained by which A and B may be determined.

Let the fraction be

$$\frac{x}{(x-1)(x^2+x+1)} = \frac{Ax + B}{x^2 + x + 1} + \frac{P}{Q}.$$

Then $x = (Ax + B)(x - 1) + P(x^2 + x + 1)$.

Now $x^2 + x + 1 = 0$ gives $x = -\frac{1}{2} \pm \frac{1}{2}\sqrt{-3}$; therefore, by substituting in the last equation, it becomes, after collecting the terms,

$$-\tfrac{1}{2} \pm \tfrac{1}{2}\sqrt{-3} = -\tfrac{3}{2}B \pm (\tfrac{1}{2}B - A)\sqrt{-3}.$$

Hence $-\frac{3}{2}B = -\frac{1}{2}$ and $\frac{1}{2}B - A = \frac{1}{2}$, therefore $B = \frac{1}{3}$ and $A = -\frac{1}{3}$.

122. In the last place, let us consider the case in which the fraction $\frac{U}{V} =$

$$\frac{Ax + B}{(x^2 + 2\alpha x + \alpha^2 + \beta^2)^n} + \frac{Cx + D}{(x^2 + 2\alpha x + \alpha^2 + \beta^2)^{n-1}} \ldots\ldots + \frac{P}{Q};$$

and here $V = (x^2 + 2\alpha x + \alpha^2 + \beta^2)^n Q$. We have now

$$\frac{U}{Q} = (Ax + B) + (Cx + D)(x^2 + 2\alpha x + \alpha^2\beta^2) \ldots$$
$$+ \frac{P}{Q}(x^2 + 2\alpha x + \alpha^2 + \beta^2)^n V.$$

This case is compounded of the two preceding, and must be treated in the same manner. In the first place, we substitute for x, one of the roots of the equation, $x^2 + 2\alpha x + \alpha^2 + \beta^2 = 0$, by which all the terms containing this quantity disappear, and the equation is reduced

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to $\frac{V}{Q} = Ax + B$; and here V and Q are functions of the particular value of x, which satisfies the above-mentioned equation. As in the last case, we shall have an equation of the form $r + s\sqrt{-1} = r' + s'\sqrt{-1}$, r and s being composed of constants and the indeterminate quantities A, B; and these last will be found from the equations

$$r = r', \quad s = s'.$$

We now differentiate the preceding equation, and, after omitting the terms in the result that contain $x^2 + 2\alpha x + \alpha^2 + \beta^2$, have

$$\frac{d\left(\frac{V}{Q}\right)}{dx} = A + (2x + 2\alpha)(Cx + D).$$

By substituting in this expression the imaginary value of x, which satisfies the equation $x^2 + 2\alpha x + \alpha^2 + \beta^2 = 0$, and putting the real and imaginary terms on each side equal, two equations will be obtained which determine C and D.

As an example, let the fraction be $\frac{x^3 - 2x^2 + x - 3}{(x^2 - 2x + 2)^2}$.

We assume it

$$= \frac{Ax + B}{(x^2 - 2x + 2)^2} + \frac{Cx + D}{x^2 - 2x + 2}.$$

By reducing to a common denominator, we find

$$x^3 - 2x^2 + x - 3 = Ax + B + (Cx + D)(x^2 - 2x + 2),$$

one of the roots of the equation $x^2 - 2x + 2 = 0$ is $x = 1 + \sqrt{-1}$; this being substituted for x, the equation, becomes

$$-4 - \sqrt{-1} = A + B + A\sqrt{-1}.$$

Hence, to determine A and B, we have $A + B = -4$, and $A = -1$; therefore $B = -3$. Substituting the values of A and B, and transposing, we have

$$x^3 - 2x^2 + 2x = (Cx + D)(x^2 - 2x + 2);$$

and, taking the differentials, and dividing by dx,

$$3x^2 - 4x + 2 = (Cx + D)(2x - 2) +, \&c.$$

By again substituting $1 + \sqrt{-1}$ for x, this equation becomes

$$-2 + 2\sqrt{-1} = -2C + 2(C + D)\sqrt{-1};$$

hence $C = 1$, $D = 0$, and the proposed fraction is equivalent to

$$-\frac{x + 3}{(x^2 - 2x + 2)^2} + \frac{x}{x^2 - 2x + 2}.$$

There is an extensive class of differentials, rational fractions, in which the denominator has the form $x^{2n} \pm 2x^n \cos \alpha + 1$; also of this form, $x^n \pm 1$. How these functions may be resolved into factors of the first and second degrees has been explained in ALGEBRA, art. 274–278. This resolution being effected, the integration may be performed as has been explained.

Integrals of Irrational Fractions.

123. When a differential involves irrational functions, if by any means these can be transformed into others entirely rational, their integration may be effected by the rules already explained.

For example, let the differential be

$$\frac{(1 + \sqrt{x} - \sqrt[3]{x^2})\,dx}{1 + \sqrt[3]{x}}$$

It is evident, that making $x = z^6$, all the extractions indicated by the radical signs may be effected; and since $dx = 6z^5dz$, the differential is transformed to

$$\frac{6z^5dz(1 + z^3 - z^4)}{1 + z^2};$$

and by actually dividing the numerator by the denominator, this last may be expressed thus,

$$-6(z^7 - z^6 - z^5 + z^4 - z^2 + 1)\,dz - \frac{6dz}{1 + z^2},$$

whose integral is

$$-6\left(\frac{z^8}{8} - \frac{z^7}{7} - \frac{z^6}{6} + \frac{z^5}{5} - \frac{z^3}{3} + z - \tan^{-1} z\right) + \text{const.}$$

By replacing the value of z, viz. $x^{\frac{1}{6}}$, the integral may be expressed in terms of x.

124. We shall now consider those irrational functions which include the radical $\sqrt{a + bx + cx^2}$ only, and which appear under one or other of the two forms,

$$Pdx\sqrt{a + bx + cx^2}, \quad \frac{Pdx}{\sqrt{a + bx + cx^2}},$$

where P denotes any rational function of x. These may, however, be included in one; for if the first be multiplied by the radical, and the same quantity written under it as a denominator, it becomes

$$\frac{P(a + bx + cx^2)dx}{\sqrt{a + bx + c^2}},$$

an expression of the same kind as the second.

We begin with the simple form, $\frac{dx}{\sqrt{a + bx + cx^2}}$, which, however, has two cases, according as the sign of c in the denominator is positive or negative.

125. I. To integrate the differential $\frac{dx}{\sqrt{a + bx + cx^2}}$.

Assume $\sqrt{a + bx + cx^2} = py + \frac{q}{y}$ ....(1)

Here p and q are indeterminate constant quantities, to which such values are to be given as shall serve to transform the proposed differential into another that may be a rational fraction; we have now

$$a + bx + cx^2 = p^2y^2 + 2pq + \frac{q^2}{y^2}.$$

To make the left-hand side of this equation a perfect square, we transpose its first term, then multiply both sides by c, and add $\frac{b^2}{4}$ to each side of the result; it then becomes

$$\frac{b^2}{4} + bcx + c^2x^2 = c\left(p^2y^2 + 2pq - a + \frac{b^2}{4c} + \frac{q^2}{y^2}\right).$$

The second side will also become a square if we make

$$2pq - a + \frac{b^2}{4c} = -2pq,$$

$$\text{or } 4pq = \frac{4ac - b^2}{4c},$$

which is evidently always a possible assumption; by this, the equation becomes

$$\frac{b^2}{4} + bcx + c^2x^2 = c\left(p^2y^2 - 2pq + \frac{q^2}{y^2}\right);$$

and hence, by taking the square roots,

$$\frac{b}{2} + cx = \sqrt{c}\left(py - \frac{q}{y}\right) \text{........................(2)}$$

From this, by differentiation, we obtain

$$\sqrt{c}\,dx = \frac{dy}{y}\left(py + \frac{q}{y}\right) = \frac{dy}{y}\sqrt{a + bx + cx^2};$$

and hence,

$$\frac{dx}{\sqrt{a + bx + cx^2}} = \frac{1}{\sqrt{c}}\frac{dy}{y} \text{.....................(3)}$$

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Dividing now both sides of equation (2) by $\sqrt{c}$, and adding the results to equation (1), we get

$$\frac{b}{2\sqrt{c}}+x\sqrt{c}+\sqrt{a+bx+cx^2}=2py;$$

and, taking the logarithms,

$$\mathrm{l.}\left(\frac{b}{2\sqrt{c}}+x\sqrt{c}+\sqrt{a+bx+cx^2}\right)=\mathrm{l.}\,y+\mathrm{l.}\,(2p)\ldots(4)$$

Now $\mathrm{l.}\,y=\int\frac{dy}{y}+\mathrm{C}$; here, C being any constant whatever, we may suppose it $=\mathrm{C}'-\mathrm{l.}\,(2p)$, where C′ denotes another indeterminate constant; therefore,

$$\mathrm{l.}\,y+\mathrm{l.}\,(2p)=\int\frac{dy}{y}+\mathrm{C}'.$$

By comparing this last equation with (3) and (4), we find

$$\int\frac{dx}{\sqrt{a+bx+cx^2}},$$

$$=\frac{1}{\sqrt{c}}\,\mathrm{l.}\left(\frac{b}{2\sqrt{c}}+x\sqrt{c}+\sqrt{a+bx+cx^2}\right)+\mathrm{C},$$

$$=\frac{1}{\sqrt{c}}\,\mathrm{l.}\left(b+2cx+2\sqrt{c}\sqrt{a+bx+cx^2}\right)+\mathrm{C}.$$

These logarithmic functions differ from each other only by the constant l $(2\sqrt{c}.)$

126. II. To integrate the differential $\frac{dx}{\sqrt{a+bx-cx^2}}$, assume $\sqrt{a+bx-cx^2}=p\sin\varphi$...........(1) p representing here an indeterminate constant, and φ a variable angle. Then

$$a+bx-cx^2=p^2\sin^2\varphi=p^2-p^2\cos^2\varphi;$$

and hence, proceeding as in last article,

$$\frac{b^2}{4}-bcx+c^2x^2=cp^2\cos^2\varphi+\frac{b^2}{4}+ac-p^2c.$$

The left-hand side of the equation is now a complete square, and to make the right also a square, we assume that

$$cp^2=\frac{b^2}{4}+ac,\ \text{or}\ p\sqrt{c}=\frac{\sqrt{b^2+4ac}}{2}\ldots\ldots\ldots(2)$$

and thus obtain

$$\frac{b^2}{4}-bcx+c^2x^2=cp^2\cos^2\varphi,$$

and, taking the square roots,

$$\frac{b}{2}-cx=\sqrt{c}\,p\cos\varphi\ldots\ldots\ldots\ldots\ldots(3)$$

and hence, differentiating, and dividing by $\sqrt{c}$,

$$dx=\frac{d\varphi}{\sqrt{c}}p\sin\varphi=\frac{d\varphi}{\sqrt{c}}\sqrt{a+bx-cx^2};$$

and hence,

$$\frac{dx}{\sqrt{a+bx-cx^2}}=\frac{1}{\sqrt{c}}d\varphi.$$

Taking now the integral, we have

$$\int\frac{dx}{\sqrt{a+bx-cx^2}}=\frac{1}{\sqrt{c}}\varphi+\text{const.}$$

To determine φ, we have, (3) and (2),

$$\cos\varphi=\frac{b-2cx}{2\sqrt{c}\,p}=\frac{b-2cx}{\sqrt{b^2+4ac}}.$$

Therefore,

$$\int\frac{dx}{\sqrt{a+bx-cx^2}}=\frac{1}{\sqrt{c}}\cos^{-1}\frac{b-2cx}{\sqrt{b^2+4ac}}+\mathrm{C}.$$

We have also

$$\int\frac{dx}{\sqrt{a+bx-cx^2}}=\frac{1}{\sqrt{c}}\sin^{-1}\frac{2cx-b}{\sqrt{b^2+4ac}}+\mathrm{C};$$

for the angle whose cosine is any number v differs from the angle whose sine is $-v$ by a right angle, which is a constant, and therefore the differentials of these angles will be the same expression.

127. We shall now integrate the formula

$$\frac{x^n dx}{\sqrt{a+bx+cx^2}},$$

n being any whole number. We put

$$\mathrm{X}=\sqrt{a+bx+cx^2},\ y=x^m\sqrt{a+bx+cx^2}=x^m\mathrm{X},$$

then $y^2=ax^{2m}+bx^{2m+1}+cx^{2m+2}$,

and differentiating, we have $2ydy=$

$$(2max^{2m-1}+(2m+1)bx^{2m}+(2m+2)cx^{2m+1})dx;$$

and hence, dividing by $y=x^m\mathrm{X}$,

$$2dy=2ma\frac{x^{m-1}dx}{\mathrm{X}}+(2m+1)b\frac{x^m dx}{\mathrm{X}}$$

$$+(2m+2)c\frac{x^{m+1}dx}{\mathrm{X}}.$$

Let us now make $m+1=n$, and therefore $m=n-1$, $m-1=n-2$, $2m=2n-2$, $2m+1=2n-1$, $2m+2=2n$; thus we obtain

$$2dy=(2n-2)a\frac{x^{n-2}dx}{\mathrm{X}}+(2n-1)b\frac{x^{n-1}dx}{\mathrm{X}}$$

$$+2nc\frac{x^n dx}{\mathrm{X}};$$

and hence, by proper arrangement of the terms,

$$\frac{x^n dx}{\mathrm{X}}=\frac{dy}{nc}-\frac{2n-1}{2n}\cdot\frac{b}{c}\cdot\frac{x^{n-1}dx}{\mathrm{X}}-\frac{n-1}{n}\cdot\frac{a}{c}\cdot\frac{x^{n-2}dx}{\mathrm{X}};$$

and, by integration, and putting for y and X the functions they represent, we have

$$\int\frac{x^n dx}{\sqrt{a+bx+cx^2}}=\frac{1}{nc}x^{n-1}\sqrt{a+bx+cx^2}$$

$$-\frac{2n-1}{2n}\cdot\frac{b}{c}\int\frac{x^{n-1}dx}{\sqrt{a+bx+cx^2}}$$

$$-\frac{n-1}{n}\cdot\frac{a}{c}\int\frac{x^{n-2}dx}{\sqrt{a+bx+cx^2}}.$$

The proposed integral is now expressed by an algebraic function, and two other integrals of the same form, but in which the exponents of x are of lower degrees. We have found its value (art. 125, 126) when $n=0$, a case to which the formula just found does not apply, because then, n entering into the denominators of the fractions, they become infinite. When $n=1$, the last of the two integrals in the second side of the equation vanishes, because its coefficient $=0$, and we have

$$\int\frac{xdx}{\sqrt{a+bx+cx^2}}=\frac{1}{c}\sqrt{a+bx+cx^2}$$

$$-\frac{b}{2c}\int\frac{dx}{\sqrt{a+bx+cx^2}}.$$

Knowing now the integrals in the cases of $n=0$ and $n=1$, the preceding general formula gives it in the case of $n=2$; and in the case of $n=3$, it is found from the cases of $n=1$ and $n=2$; and so on to any extent, supposing n to be a positive number.

128. When n is negative, the formula will be better under another form. Writing $-n$ instead of $+n$, and arranging the terms of the result anew, we have

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$$\int\frac{dx}{x^n\sqrt{a+bx+cx^2}}=\frac{-1}{(n-1)a}\cdot\frac{\sqrt{a+bx+cx^2}}{x^{n-1}}$$
$$-\frac{2n-3}{2n-2}\cdot\frac{b}{a}\int\frac{dx}{x^{n-1}\sqrt{a+bx+cx^2}}$$
$$-\frac{n-2}{n-1}\cdot\frac{c}{a}\int\frac{dx}{x^{n-2}\sqrt{a+bx+cx^2}}.$$

In this formula, n is understood to be positive.

129. This formula of transformation will not apply to the case of $n=1$, because then the fractions which have $n-1$ in the denominator become infinite. It is therefore necessary to investigate the integral of $\frac{dx}{x\sqrt{a+bx+cx^2}}$ separately. Let $x=\frac{1}{y}$; then $\frac{dx}{x}=\frac{-dy}{y}$, and

$$\frac{dx}{x\sqrt{a+bx+cx^2}}=\frac{-dy}{\sqrt{c+by+ay^2}}.$$

This transformed differential has two cases, according as a is positive or negative; when a is positive, the integral is, by article 125,

$$-\frac{1}{\sqrt{a}}\,\mathrm{l.}\,(b+2ay+2\sqrt{a}\,\sqrt{c+by+ay^2})+\mathrm{C}.$$

We are at liberty to give the radical $\sqrt{a}$ either the sign $+$ or the sign $-$; therefore, giving it the latter, the integral is

$$\frac{1}{\sqrt{a}}\,\mathrm{l.}\,(b+2ay-2\sqrt{a}\,\sqrt{c+by+ay^2})+\mathrm{C};$$

and hence, substituting for y its equivalent $\frac{1}{x}$, we have

$$\int\frac{dx}{x\sqrt{a+bx+cx^2}}$$
$$=\frac{1}{\sqrt{a}}\,\mathrm{l.}\,\frac{2a+bx-2\sqrt{a}\,\sqrt{a+bx+cx^2}}{x}+\mathrm{C};$$

observing, as above stated, that the radical $\sqrt{a}$ may have the sign $+$ and also the sign $-$.

In the second case we have

$$\frac{dx}{x\sqrt{-a+bx+cx^2}}=\frac{-dy}{\sqrt{c+by-ay^2}}.$$

Now, by art. 126,

$$\int\frac{-dy}{\sqrt{c+by-a^2y^2}}=-\frac{1}{\sqrt{a}}\sin^{-1}\frac{2ay-b}{\sqrt{b^2+4ac}}+\mathrm{C}$$
$$=\frac{1}{\sqrt{a}}\cos^{-1}\frac{2ay-b}{\sqrt{b^2+4ac}}+\mathrm{C}.$$

Therefore, putting $\frac{1}{x}$ instead of y,

$$\int\frac{dx}{x\sqrt{-a+bx+cx^2}}=\frac{1}{\sqrt{a}}\cos^{-1}\frac{2a-bx}{x\sqrt{b^2+4ac}}+\mathrm{C}.$$

130. The formulæ investigated from articles 125 to 128 serve for the integration of innumerable differentials. Thus, from art. 125 we have

$$\int\frac{dx}{\sqrt{a+x^2}}=\mathrm{l.}\,(x+\sqrt{a+x^2})+\mathrm{C}$$

$$\int\frac{dx}{\sqrt{bx+x^2}}=\mathrm{l.}\,(\tfrac{1}{2}b+x+\sqrt{bx+x^2})+\mathrm{C};$$

and, from the first formula of art. 129

$$\int\frac{adx}{x\sqrt{a^2+cx^2}}=\mathrm{l.}\,\frac{2a^2-2a\sqrt{a^2+cx^2}}{x}+\mathrm{C}$$

$$=\mathrm{l.}\,\frac{a-\sqrt{a^2+cx^2}}{x}+\mathrm{C}.$$

The second of these integrals is obtained from the first by passing l. $(2a)$ into the arbitrary constant C. It may yet have another form; for

$$\int\frac{2adx}{x\sqrt{a^2+cx^2}}=\mathrm{l.}\,\frac{(a-\sqrt{a^2+cx^2})}{-cx^2}+\mathrm{C}.$$

Now $-cx^2=(a+\sqrt{a^2+cx^2})(a-\sqrt{a^2+cx^2})$; therefore, substituting and reducing,

$$\int\frac{adx}{x\sqrt{a^2+cx^2}}=\tfrac{1}{2}\,\mathrm{l.}\,\frac{a-\sqrt{a^2+cx^2}}{a+\sqrt{a^2+cx^2}}+\mathrm{C}.$$

This example shows that the integral is much modified by the arbitrary constant which enters it.

131. Corresponding to these logarithmic integrals there is a set of similar integrals which are expressed by angles or arcs of a circle. Thus we have, art. 126,

$$\int\frac{dx}{\sqrt{a^2-x^2}}=\sin^{-1}\frac{x}{a}+\mathrm{C},$$
$$\int\frac{dx}{\sqrt{ax-x^2}}=\cos^{-1}\left(1-2\frac{x}{a}\right)+\mathrm{C},$$

and by formula 2 of art. 129,

$$\frac{adx}{x\sqrt{x^2-a^2}}=\sec^{-1}\frac{x}{a}+\mathrm{C}=\cos^{-1}\frac{a}{x}+\mathrm{C}.$$

132. As an example of the way of proceeding in the integration of a differential which involves radical quantities, let it be proposed to integrate the differential

$$\frac{dx}{x}\sqrt{\frac{a^2-x^2}{x^2-b^2}}.$$

By an obvious transformation, we find

$$\frac{dx}{x}\sqrt{\frac{a^2-x^2}{x^2-b^2}}=\frac{a^2dx}{x\sqrt{\{(a^2-x^2)(x^2-b^2)\}}}$$
$$-\frac{xdx}{\sqrt{\{(a^2-x^2)(x^2-b^2)\}}}.$$

The first of these differentials may be otherwise expressed thus,

$$-\frac{a}{b}\,\frac{\frac{1}{x}\,d\left(\frac{1}{x}\right)}{\sqrt{\left\{\left(\frac{1}{a^2}-\frac{1}{x^2}\right)\left(\frac{1}{x^2}-\frac{1}{b^2}\right)\right\}}}.$$

Therefore we have

$$\frac{dx}{x}\sqrt{\frac{a^2-x^2}{x^2-b^2}}=\frac{-xdx}{\sqrt{\{(a^2-x^2)(x^2-b^2)\}}}$$
$$-\frac{a}{b}\,\frac{\frac{1}{x}\,d\left(\frac{1}{x}\right)}{\sqrt{\left\{\left(\frac{1}{a^2}-\frac{1}{x^2}\right)\left(\frac{1}{x^2}-\frac{1}{b^2}\right)\right\}}},$$

and it is evident that the two differentials have precisely the same form.

To integrate the first of these, let us assume

$$x^2=a^2\cos^2\varphi+b^2\sin^2\varphi;$$
$$\text{then } xdx=(b^2-a^2)\sin\varphi\cos\varphi\,d\varphi,$$
$$a^2-x^2=(a^2-b^2)\sin^2\varphi\ldots\ldots\ldots\ldots(1)$$
$$x^2-b^2=(a^2-b^2)\cos^2\varphi\ldots\ldots\ldots\ldots(2)$$
$$\frac{-xdx}{\sqrt{\{(a^2-x^2)(x^2-b^2)\}}}=\frac{(a^2-b^2)\cos\varphi\sin\varphi\,d\varphi}{(a^2-b^2)\cos\varphi\sin\varphi}=d\varphi,$$

Exactly in the same way, if we make

$$\frac{1}{x^2}=\frac{1}{a^2}\cos^2\psi+\frac{1}{b^2}\sin^2\psi,$$

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we get

$$\frac{1}{x}d\left(\frac{1}{x}\right)=\left(\frac{1}{b^2}-\frac{1}{a^2}\right)\sin\psi\cos\psi d\psi,$$

$$\frac{1}{a^2}-\frac{1}{x^2}=\left(\frac{1}{a^2}-\frac{1}{b^2}\right)\sin^2\psi\ldots\ldots\ldots\ldots(3)$$

$$\frac{1}{x^2}-\frac{1}{b^2}=\left(\frac{1}{a^2}-\frac{1}{b^2}\right)\cos^2\psi\ldots\ldots\ldots\ldots(4)$$

$$\frac{-\frac{1}{x}d\left(\frac{1}{x}\right)}{\sqrt{\left\{\left(\frac{1}{a^2}-\frac{1}{x^2}\right)\left(\frac{1}{x^2}-\frac{1}{b^2}\right)\right\}}}=\frac{\left(\frac{1}{b^2}-\frac{1}{a^2}\right)\sin\psi\cos\psi d\psi}{\left(\frac{1}{b^2}-\frac{1}{a^2}\right)\sin\psi\cos\psi}=d\psi.$$

On the whole, if φ and ψ be such angles that

$$\cos\varphi=\sqrt{\frac{x^2-b^2}{a^2-b^2}},\quad \cos\psi=\frac{a}{x}\cos\varphi;$$

then

$$\int\frac{dx}{x}\sqrt{\frac{a^2-x^2}{x^2-b^2}}=\varphi+\frac{a}{b}\psi+\text{const.}$$

Integration of Binomial Differentials.

133. These differentials are represented by the formula

$$x^{m-1}dx\,(a+bx^n)^{\frac{p}{q}},$$

whose generality will not be affected by supposing that m and n are whole numbers. The object we propose is to find in what case this differential may be made rational.

We assume $a+bx^n=z^q$, so that $(a+bx^n)^{\frac{p}{q}}=z^p$; we then find

$$x^n=\frac{z^q-a}{b},\quad x^m=\left(\frac{z^q-a}{b}\right)^{\frac{m}{n}},$$

$$x^{m-1}dx=\frac{q}{nb}z^{q-1}\left(\frac{z^q-a}{b}\right)^{\frac{m}{n}-1}dz;$$

and the proposed differential is now transformed into

$$\frac{q}{nb}z^{p+q-1}\,dz\left(\frac{z^q-a}{b}\right)^{\frac{m}{n}-1},$$

an expression which is evidently rational whenever $\frac{m}{n}$ is a whole number.

The differential $x^8dx\,(a+bx^3)^{\frac{p}{q}}$ satisfies this condition, since $m=9$, $n=3$, $\frac{m}{n}=3$, and it is transformed into

$$\frac{q}{3b}z^{p+q-1}\,dz\left(\frac{z^q-a}{b}\right)^2.$$

The differential $x^{m-1}\,dx\,(a+bx^n)^{\frac{p}{q}}$ admits of another form, by making the index of x between the brackets negative, or by dividing the quantity $a+bx^n$ by x^n; then we have

$$x^{m-1}dx\,(a+bx^n)^{\frac{p}{q}}=x^{m-1}dx\,\{(ax^{-n}+b)\,x^n\}^{\frac{p}{q}}$$
$$=x^{m+\frac{np}{q}-1}\,dx\,(ax^{-n}+b)^{\frac{p}{q}};$$

and by the process preceding, the last of these expressions may be made rational, whenever $\dfrac{m+\frac{np}{q}}{n}$ is a whole number; or, what is the same thing, whenever $\frac{m}{n}+\frac{p}{q}$ is an integer.

The differential $x^4\,dx\,(a+bx^3)^{\frac{1}{3}}$ is of this description, since $\frac{m}{n}=\frac{5}{3}$, $\frac{p}{q}=\frac{1}{3}$, $\frac{m}{n}+\frac{p}{q}=\frac{6}{3}=2$.

In applying to the differential

$$x^{m+\frac{np}{q}-1}\,dx\,(ax^{-n}+b)^{\frac{p}{q}},$$

the substitution indicated for the first form of this differential, we shall make $ax^{-n}+b=z^q$, and thence deduce $a+bx^n=x^n z^q$; and if we transform immediately the expression $x^{m-1}\,dx\,(a+bx^n)^{\frac{p}{q}}$ by means of the equation preceding, we shall evidently obtain the same result as if we had at first given it the form

$$x^{m+\frac{np}{q}-1}\,dx(ax^{-n}+b)^{\frac{p}{q}}.$$

134. Since it is not possible to integrate in every case the formula $x^{m-1}\,dx\,(a+bx^n)^{\frac{p}{q}}$, we may try to change it into another more simple, as has been done in integrating a differential (art. 115). We have found that $\int udv=uv-\int vdu$. If therefore we can decompose the differential into two factors, one of which being integrable, may be represented by dv, and the other by u, the integration of the proposed differential will be made to depend on that of vdu, which in some cases will be more simple than the proposed differential. This method, which is at once extensive and elegant, is called *integration by parts.*

For the sake of abridging, we shall write simply p instead of $\frac{p}{q}$, supposing p to represent a fractional number. The formula will then become

$$x^{m-1}\,dx\,(a+bx^n)^p.$$

Among the different ways of resolving this differential into factors, we choose this:

$$x^{m-n}\,x^{n-1}\,dx\,(a+bx^n)^p.$$

One of the factors, $x^{n-1}\,dx\,(a+bx^n)^p$, is integrable, whatever be the value of p (art. 108); representing it therefore by dv, we have

$$v=\frac{(a+bx^n)^{p+1}}{nb\,(p+1)},\text{ and }u=x^{m-n},$$

whence there results

$$\int x^{m-1}dx\,(a+bx^n)^p=\frac{x^{m-n}(a+bx^n)^{p+1}}{nb\,(p+1)},$$
$$-\frac{m-n}{nb\,(p+1)}\int x^{m-n-1}\,dx\,(a+bx^n)^{p+1};$$

but $\int x^{m-n-1}\,dx\,(a+bx^n)^{p+1}$

$$=\int x^{m-n-1}\,dx\,(a+bx^n)^p\,(a+bx^n)=$$
$$a\int x^{m-n-1}\,dx\,(a+bx)^p+$$
$$b\int x^{m-1}\,dx\,(a+bx^n)^p,$$

putting this last in the preceding equation; and collecting the terms containing the integral $\int x^{m-1}dx(a+bx^n)^p$, we obtain, after reduction,

(A.)

$$\int x^{m-1}dx\,(a+bx^n)^p = \frac{x^{m-n}(a+bx^n)^{p+1}}{b\,(pn+m)}$$
$$-\frac{a\,(m-n)}{b\,(pn+m)}.\int x^{m-n-1}dx\,(a+bx^n)^p.$$

It is obvious that since we may reduce the integration of $x^{m-1}dx\,(a+bx^n)^p$ to that of $x^{m-n-1}dx\,(a+bx^n)^p$, we may reduce this last to the integration of $x^{m-2n-1}dx\,(a+bx^n)^p$ by writing $m-n$ in the place of m in equation (A); then, by changing $m-n$ into $m-2n$, we shall be able to determine $\int x^{m-2n-1}dx\,(a+bx^n)^p$ by means of $\int x^{m-3n-1}dx\,(a+bx^n)^p$, and so on.

In general, if r denote the number of reductions, we shall at last come to $\int x^{m-rn-1}dx\,(a+bx^n)^p$, and the last formula will be

$$\int x^{m-(r-1)n-1}dx\,(a+bx^n)^p$$
$$=\frac{x^{m-rn}(a+bx^n)^{p+1}}{b\{pn+m-(r-1)n\}}-$$
$$\frac{a\,(m-rn)}{b\,\{pn+m-(r-1)n\}}\int x^{m-rn-1}dx\,(a+bx^n)^p.$$

It appears from this formula, that if m be a multiple of n, the integration of the proposed formula $x^{m-1}dx\,(a+bx^n)^p$ may be effected in algebraic terms, since the last integral of the transformed expression will be multiplied by $m-rn=0$. This result agrees with that of art. 133.

135. There is another way of reduction by which the exponent of the quantity within the parenthesis may be diminished by an unit; for this purpose it is only necessary to observe that

$$\int x^{m-1}dx(a+bx^n)^p$$
$$=\int x^{m-1}dx(a+bx^n)^{p-1}(a+bx^n)$$
$$=a\int x^{m-1}dx(a+bx^n)^{p-1}$$
$$+\,b\int x^{m+n-1}dx(a+bx^n)^{p-1}.$$

Formula (A), by changing m into $m+n$, and p into $p-1$, gives

$$\int x^{m+n-1}dx(a+bx^n)^{p-1}=$$
$$\frac{x^m(a+bx^n)^p-am\int x^{m-1}dx(a+bx^n)^{p-1}}{b(pn+m)}.$$

Substituting this value in the preceding equation, we have

(B)

$$\int x^{m-1}dx(a+bx^n)^p=\frac{x^m(a+bx^n)^p}{pn+m}$$
$$+\,\frac{pna}{pn+m}\int x^{m-1}dx(a+bx^n)^{p-1}.$$

By this formula we may take away successively from p as many units as it contains; and by its application, along with formula (A), we may make the integral

$$\int x^{m-1}dx(a+bx^n)^p \text{ depend on}$$

$\int x^{m-rn-1}dx(a+bx^n)^{p-s}$, rn being the greatest multiple of m contained in $m-1$, and s the greatest whole number contained in p.

The integral $\int x^7dx(a+bx^3)^{\frac{5}{2}}$, for example, may be reduced by formula (A) successively to

$$\int x^4dx(a+bx^3)^{\frac{5}{2}},\ \int xdx(a+bx^3)^{\frac{5}{2}};$$

and by formula (B), $\int xdx(a+bx^3)^{\frac{5}{2}}$ is reduced to

$\int xdx(a+bx^3)^{\frac{3}{2}}$, and that again to $\int xdx(a+bx^3)^{\frac{1}{2}}$.

136. It is evident that if m and n were negative, the formulæ (A) and (B) would not accomplish the purpose for which they have been investigated; they would then increase the exponent of x without the parenthesis, as well as that of the parenthesis itself; but by reversing them we shall find others suited to the case in question. From formula (A) we deduce

$$\int x^{m-n-1}dx(a+bx^n)^p=\frac{x^{m-n}(a+bx^n)^{p+1}}{a(m-n)},$$
$$-\frac{b(m+np)}{a(m-n)}\int x^{m-1}dx(a+bx^n)^p.$$

In this expression, substitute $m+n$ in place of m and it becomes

(C)

$$\int x^{m-1}dx(a+bx^n)^p=\frac{x^m(a+bx^n)^{p+1}}{am}$$
$$-\frac{b(m+n+np)}{am}\int x^{m+n-1}dx(a+bx^n)^p.$$

This formula diminishes the exponent without the parenthesis, since $m+n-1$ becomes $-m+n-1$ when $-m$ is put instead of $+m$.

To reverse the formula (B), we take

$$\int x^{m-1}dx(a+bx^n)^{p-1}=-\frac{x^m(a+bx^n)^p}{pna}$$
$$+\frac{m+np}{pna}\int x^{m-1}dx(a+bx^n)^p;$$

then we write $p+1$ instead of p, and thus find formula

(D)

$$\int x^{m-1}dx(a+bx^n)^p=-\frac{x^m(a+bx^n)^{p+1}}{na(p+1)}$$
$$+\frac{m+n+np}{na(p+1)}\int x^{m-1}dx(a+bx^n)^{p+1}.$$

This formula answers the proposed purpose, since $p+1$ becomes $-p+1$, when p is negative.

137. Let the formula be $\int\frac{x^{m-1}dx}{\sqrt{1-x^2}}$, where m is a whole positive number. Making $a=1$, $b=-1$, $n=2$, $p=-\frac{1}{2}$, we find

$$\int\frac{x^{m-1}dx}{\sqrt{1-x^2}}=-\frac{x^{m-2}\sqrt{1-x^2}}{m-1}+\frac{m-2}{m-1}\int\frac{x^{m-3}dx}{\sqrt{1-x^2}}.$$

Writing m in place of $m-1$, we have

$$\int\frac{x^m dx}{\sqrt{1-x^2}}=-\frac{x^{m-1}\sqrt{1-x^2}}{m}+\frac{m-1}{m}\int\frac{x^{m-2}\,dx}{\sqrt{1-x^2}}.$$

If we give to m successive different values, beginning with the uneven numbers, we have

$$\int\frac{x\,dx}{\sqrt{1-x^2}}=-\sqrt{1-x^2}+\text{const.}$$

$$\int\frac{x^3dx}{\sqrt{1-x^2}}=-\tfrac{1}{3}x^2\sqrt{1-x^2}+\tfrac{2}{3}\int\frac{x\,dx}{\sqrt{1-x^2}},$$

$$\int\frac{x^5dx}{\sqrt{1-x^2}}=-\tfrac{1}{5}x^4\sqrt{1-x^2}+\tfrac{4}{5}\int\frac{x^3dx}{\sqrt{1-x^2}},$$

$$\int\frac{x^7dx}{\sqrt{1-x^2}}=-\tfrac{1}{7}x^6\sqrt{1-x^2}+\tfrac{6}{7}\,\frac{x^5dx}{\sqrt{1-x^2}},$$

&c.

and hence we deduce

$$\int\frac{x^3dx}{\sqrt{1-x^2}}=-\left(\tfrac{1}{3}x^2+\frac{1.2}{1.3}\right)\sqrt{1-x^2},$$

$$\int\frac{x^5dx}{\sqrt{1-x^2}}=-\left(\tfrac{1}{5}x^4+\frac{1.4}{3.5}x^2+\frac{1.2.4}{1.3.5}\right)\sqrt{1-x^2},$$

$$\int\frac{x^7dx}{\sqrt{1-x^2}}=-\left(\tfrac{1}{7}x^6+\frac{1.6}{5.7}x^4+\frac{1.4.6}{3.5.7}x^2\right.$$
$$\left.+\frac{1.2.4.6}{1.3.5.7}\right)\sqrt{1-x^2},$$

&c.

The law of formation of the integrals is evident; an arbitrary constant is to be annexed to each.

Let us now consider the even values of m. Supposing $m=2, 4, 6$, &c. we have

$$\int\frac{x^2dx}{\sqrt{1-x^2}}=-\tfrac{1}{2}x\sqrt{1-x^2}+\tfrac{1}{2}\int\frac{dx}{\sqrt{1-x^2}},$$

$$\int\frac{x^4dx}{\sqrt{1-x^4}}=-\tfrac{1}{4}x^3\sqrt{1-x^2}+\tfrac{3}{4}\int\frac{x^2dx}{\sqrt{1-x^2}},$$

$$\int\frac{x^6dx}{\sqrt{1-x^2}}=-\tfrac{1}{6}x^5\sqrt{1-x^2}+\tfrac{5}{6}\int\frac{x^4dx}{\sqrt{1-x^2}}.$$

&c.

Here all the integrals depend on

$$\int\frac{dx}{\sqrt{1-x^2}}=\sin^{-1}x+\text{const. (art. 23.)}$$

Let us call A the arc whose sine is x, and we have

$$\int\frac{dx}{\sqrt{1-x^2}}=\text{A}+\text{const.}$$

$$\int\frac{x^2dx}{\sqrt{1-x^2}}=-\tfrac{1}{2}x\sqrt{1-x^2}+\tfrac{1}{2}\text{A}+\text{const.}$$

$$\int\frac{x^4dx}{\sqrt{1-x^2}}=-\left(\tfrac{1}{4}x^3+\frac{1.3}{2.4}x\right)\sqrt{1-x^3}$$
$$+\frac{1.3}{2.4}\text{A}+\text{const.}$$

$$\int\frac{x^6dx}{\sqrt{1-x^2}}=-\left(\tfrac{1}{6}x^5+\frac{1.5}{4.6}x^3+\frac{1.3.5}{2.4.6}x\right)\sqrt{1-x^2}$$
$$+\frac{1.3.5}{2.4.6}\text{A}+\text{const.}$$

138. Let us now consider the formulæ which answer to the case of m negative; then by formula (C) art. 136,

$$\int\frac{x^{-m-1}dx}{\sqrt{1-x^2}}=-\frac{x^{-m}\sqrt{1-x^2}}{m}$$
$$+\frac{m-1}{m}\int\frac{x^{-m+1}dx}{\sqrt{1-x^2}}.$$

Writing $-m$ instead of $-m-1$, this becomes

$$\int\frac{dx}{x^m\sqrt{1-x^2}}=\frac{-\sqrt{1-x^2}}{(m-1)x^{m-1}}$$
$$+\frac{m-2}{m-1}\int\frac{dx}{x^{m-2}\sqrt{1-x^2}}.$$

We cannot make $m=1$, because that value would make the denominator *zero* and the co-efficient infinite. We have already found the integral in this case, viz.

$$\int\frac{dx}{x\sqrt{1-x^2}}=+\,\text{l.}\frac{1-\sqrt{1-x^2}}{x}+\text{const. (art. 130).}$$

Proceeding now, making $m=3$, $m=5$, &c. we have

$$\int\frac{dx}{x^3\sqrt{1-x^2}}=-\frac{\sqrt{1-x^2}}{2x^2}+\tfrac{1}{2}\int\frac{dx}{x\sqrt{1-x^2}},$$

$$\int\frac{dx}{x^5\sqrt{1-x^2}}=-\frac{\sqrt{1-x^2}}{4x^4}+\tfrac{3}{4}\int\frac{dx}{x^3\sqrt{1-x^2}},$$

$$\int\frac{dx}{x^7\sqrt{1-x^2}}=-\frac{\sqrt{1-x^2}}{6x^6}+\tfrac{5}{6}\int\frac{dx}{x^5\sqrt{1-x^2}}.$$

&c.

Making $m=2$, $m=4$, $m=6$, &c. we find

$$\int\frac{dx}{x^2\sqrt{1-x^2}}=-\frac{\sqrt{1-x^2}}{x}+\text{const.}$$

$$\frac{dx}{x^4\sqrt{1-x^4}}=-\frac{\sqrt{1-x^2}}{3x^3}+\tfrac{2}{3}\int\frac{dx}{x^2\sqrt{1-x^2}},$$

$$\frac{dx}{x^6\sqrt{1-x^6}}=-\frac{\sqrt{1-x^2}}{5x^5}+\tfrac{4}{5}\int\frac{dx}{x^4\sqrt{1-x^2}},$$

&c.

From these two series of equations we deduce, as in the former article, a series of differentials integrated by logarithms, and another by algebraic formulæ.

Integration by Series.

139. The integral $\int \text{X}\,dx$ is easily found when the function X is expanded into a series, because then we have only to integrate a series of single terms in succession, to which the rule of art. 104 immediately applies.

Thus, let $\text{X}=\text{A}x^m+\text{B}x^{m+n}+\text{C}x^{m+2n}+\text{D}x^{m+3n}+$ &c. If both members of this equation be multiplied by dx, and each term be separately integrated, we have

$$\int\text{X}\,dx=\frac{\text{A}x^{m+1}}{m+1}+\frac{\text{B}x^{m+n+1}}{m+n+1}+\frac{\text{C}x^{m+2n+1}}{m+2n+1}+\text{\&c.}+c.$$

If in the expansion of X any term of the form $\frac{\text{E}}{x}$ occur, the integral corresponding to that term will be E l. x (art. 20). We shall now give particular examples.

Ex. 1. To integrate $\frac{dx}{a+x}$ by a series.

We know that the integral comprehends in it Napier's logarithm of $a+x$ (art. 20). Now, by division,

$$\frac{1}{a+x}=\frac{1}{a}-\frac{x}{a^2}+\frac{x^2}{a^3}-\frac{x^3}{a^4}+\frac{x^5}{a^6}-\text{\&c.}$$

Therefore, multiplying by dx, and integrating,

$$\int\frac{dx}{a+x}=\frac{x}{a}-\frac{x^2}{2a^2}+\frac{x^3}{3a^3}-\frac{x^4}{4a^4}+\text{\&c.}+\text{C.}$$

This series expresses the general integral, without any regard to its particular application. If, however, we consider it as expressing l. $(a+x)$, then we have

Inverse Method.

$$\text{l.}\,(a+x)=\frac{x}{a}-\frac{x^2}{2a^2}+\frac{x^3}{3a^3}-\frac{x^4}{4a^4}+\&c.+C.$$

The constant quantity C is now no longer indeterminate; it must have such a value as satisfies this equation whatever be the value of x. If we make $x=0$, then all the terms of the series vanish, and we have $\text{l.}\,a=C$.

Thus the value of C is determined, and we have

$$\text{l.}\,(a+x)=\text{l.}\,a+\frac{x}{a}-\frac{x^2}{2a^2}+\frac{x^3}{3a^3}-\&c.$$

This result agrees with what we found (art. 86).

Ex. 2. To integrate $\frac{dx}{1+x^2}$ by a series. By division,

$$\frac{1}{1+x^2}=1-x^2+x^4-x^6+\&c.$$

Multiplying now both sides of this equation by dx, and integrating, we have

$$\int\frac{dx}{1+x^2}=x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\&c.+C.$$

As a formula purely analytical, the constant C must be regarded as indeterminate. We know, however, that $\frac{dx}{1+x^2}$ is the integral of an arc of which x is the tangent, the radius being unity (art. 22, Ex. 3). Therefore, if we mean to express $\tan^{-1}x$ by a series, then

$$\tan^{-1}x=x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\&c.+C.$$

The constant C has now a precise value, and it may be found by giving any corresponding known values to $\tan^{-1}x$ and x. Now we know that when $\tan^{-1}x=0$, then $x=0$. Therefore, considering that when all the terms in the series vanish, we have $0=0+C$; thus it appears that $C=0$.

Ex. 3. In the last example, the integral of $\frac{dx}{1+x^2}$ was expressed by a series of terms formed from the ascending powers of x. We may, however, express that integral by a descending series. By division

$$\frac{1}{x^2+1}=\frac{1}{x^2}-\frac{1}{x^4}+\frac{1}{x^6}-\&c.$$

And $\int\frac{dx}{x^2+1}=-\frac{1}{x}+\frac{1}{3x^3}-\frac{1}{5x^5}+\&c.+C.$

If we now regard the integral as the angle or arc whose tangent is x, we have

$$\tan^{-1}x=\frac{-1}{x}+\frac{1}{3x^3}-\frac{1}{5x^5}+\&c.+C.$$

The value of C cannot now be found by making $x=0$, because then the arc $=0$, and the substitution of $x=0$ makes all the terms of the series infinite. If we suppose the arc to be a quadrant $=\frac{\pi}{2}$, then x is infinite, and the terms of the series are each $=0$; by this assumption, $\frac{1}{2}\pi=C$. We have now

$$\tan^{-1}x=\tfrac{1}{2}\pi-\frac{1}{x}+\frac{1}{3x^3}-\frac{1}{5x^5}+\&c.$$

Ex. 4. The differential of the arc whose sine is x is $\frac{dx}{\sqrt{1-x^2}}$. It is proposed to integrate this differential by a series.

By the binomial theorem, $\frac{1}{\sqrt{1-x^2}}=(1-x^2)^{-\frac{1}{2}}=$

$$1+\tfrac{1}{2}x^2+\frac{1.3}{2.4}x^4+\frac{1.3.5}{2.4.6}x^6+\frac{1.3.5.7}{2.4.6.8}x^8+\&c.$$

Hence we have $\sin^{-1}x=\int\frac{dx}{\sqrt{1-x^2}}=$

$$x+\frac{1.x^3}{2.3}+\frac{1.3x^5}{2.4.5}+\frac{1.3.5x^7}{2.4.6.7}+\&c.$$

When the arc $=0$, then the sine $=0$; therefore both sides of this equation vanish together, and no constant is wanted to adjust it to equality.

140. The object of integration by series being to obtain approximate values of the integrals when they cannot be found accurately, it is important to have several series, so that we may be able to choose one convergent for a proposed value of x. Ascending series, or those which proceed by positive and increasing powers of x, do not converge sufficiently unless x be a small fraction, as happens with the series of Ex. 2; whilst those which proceed by the negative powers of x, or descending series, converge only so as to be of use when x is a large number.

141. In having recourse to series, it is sufficient to find one, of which the terms are separately integrable, although each may not have the form $Ax^{\frac{m}{n}}dx$; they may have any form, the integral of which can be expressed by an algebraic quantity, or a logarithm, or an arc of a circle; or, in short, any function, the numerical value of which is most readily obtained, provided always that the convergency be such as to admit of the sum of all the terms which are not taken in being rejected, because of its smallness in comparison to the sum of the terms taken in.

In the application of the calculus recourse is only to be had to series as a last resource, when the integral, from its nature, cannot be found in finite terms, or by logarithms or arcs of a circle, which in fact are the sums of infinite series. Indeed it would be very convenient to have various other tables, ready computed, of the value of a function corresponding to given successive values of the variable. The labour of their computation, their necessary great extent, and the infrequency of their use, have hitherto limited this valuable aid in calculation to a table of Napier's Logarithms, in addition to the Trigonometrical Tables.

Integration of Logarithmic Functions.

142. Let it be required to integrate $Pdx\,(\text{l.}\,x)^n$, that is, the nth power of Napier's logarithm of x multiplied by Pdx, P being an algebraic function of x. Here we apply the formula $\int udv=uv-\int vdu$; and making $u=(\text{l.}\,x)^n$, from which we find $du=n\,(\text{l.}\,x)^{n-1}\frac{dx}{x}$, also $dv=Pdx$, we have, making in order to abridge $\int Pdx=N$,

$$\int Pdx\,(\text{l.}x)^n=N\,(\text{l.}\,x)^n-n\int\frac{dx}{x}\,(\text{l.}\,x)^{n-1}N.$$

If now we represent the integral $\int\frac{dx}{x}N$ by M, we shall have

$$\int\frac{dx}{x}N(\text{l.}x)^{n-1}=M\,(\text{l.}x)^{n-1}-(n-1)\int\frac{dx}{x}(\text{l.}\,x)^{n-2}M.$$

By this reduction the proposed integral is made to depend on another of the same kind, in which the exponent of the logarithm is an unit less. Thus, if $P=x^m$, we have

$$\int x^m dx\,(\text{l.}\,x)^n=\frac{x^{m+1}}{m+1}(\text{l.}\,x)^n-\frac{n}{m+1}\int(\text{l.}x)^{n-1}x^m dx.$$

Inverse Method.

By applying the formula to this last integral, and again to the result, we find $\int x^m dx\,(\mathrm{l}.\,x)^n =$

$$x^{m+1}\left\{\frac{(\mathrm{l}.\,x)^n}{m+1}-\frac{n(\mathrm{l}.\,x)^{n-1}}{(m+1)^2}+\frac{n(n-1)(\mathrm{l}.\,x)^{n-2}}{(m+1)^3}-\&c.\right\}+\mathrm{C}.$$

It is evident that this will always terminate when n is a whole number.

143. If n be a whole negative number, we must apply the formula $\int udv = uv - \int vdu$ so as to increase the exponent of the logarithm. Thus in the differential

$$\frac{\mathrm{P}dx}{(\mathrm{l}.\,x)^n}=\frac{\mathrm{P}x}{-n+1}\cdot(-n+1)(\mathrm{l}.\,x)^{-n}\,\frac{dx}{x},$$

we make $\mathrm{P}x = u$, and $(\mathrm{l}.\,x)^{-n}\dfrac{dx}{x} = dv$, by which $\dfrac{(\mathrm{l}.\,x)^{-n+1}}{-n+1} = v$; for then we have $\int\dfrac{\mathrm{P}dx}{(\mathrm{l}.x)^n} =$

$$\frac{\mathrm{P}x}{-n+1}(\mathrm{l}.\,x)^{-n+1}+\frac{1}{n-1}\int(\mathrm{l}.\,x)^{-n+1}\,d(\mathrm{P}x).$$

Let us suppose $\mathrm{P} = x^m$, then this formula becomes

$$\int\frac{x^m dx}{(\mathrm{l}.x)^n}=\frac{-x^{m+1}}{(n-1)(\mathrm{l}.\,x)^{n-1}}+\frac{m+1}{n-1}\int\frac{x^m dx}{(\mathrm{l}.\,x)^{n-1}}.$$

By repetitions of this transformation, we at last make the proposed integral depend on $\int\dfrac{x^m dx}{\mathrm{l}.\,x}$. Now, put $x^{m+1} = z$, then $\mathrm{l}.\,x = \dfrac{\mathrm{l}.\,z}{m+1}$ and $x^m dx = \dfrac{dz}{m+1}$, therefore

$$\frac{x^m dx}{\mathrm{l}.\,x}=\frac{dz}{\mathrm{l}.\,z}.$$

The integral of this last quantity is a transcendental of a peculiar kind, which cannot be otherwise expressed than by infinite series.

Integration of Exponential Functions.

144. It appears from art. 19, that $d(a^x) = \mathrm{l}.(a)\,a^x\,dx$, therefore

$$\int a^x dx = \frac{a^x}{\mathrm{l}.\,a}+\mathrm{C}.$$

And because $dx = \dfrac{d(a^x)}{a^x\,\mathrm{l}.\,a}$; therefore, if V be any algebraic function of a^x, then, putting $a^x = u$, we have $\mathrm{V}dx = \dfrac{\mathrm{V}du}{u\,\mathrm{l}.\,a}$, an expression which, in respect of u, has an algebraic form.

For example, let $\mathrm{V} = \dfrac{a^x}{\sqrt{1+a^{nx}}}$, then,

$$\int\frac{a^x dx}{\sqrt{1+a^{nx}}}=\int\frac{du}{\mathrm{l}.\,a\sqrt{1+u^n}}.$$

The integral of this last expression may be found by rules which have been investigated.

Let z be any function of x, then, e being the number of which Nap. log $= 1$, we have $d(ze^x) = e^x dz + e^x z dx$, therefore

$$\int e^x dx\left(z+\frac{dz}{dx}\right)=ze^x+\mathrm{C}.$$

For example, let $z = x^3 - 1$, then $\dfrac{dz}{dx} = 3x^2$, and

$$\int e^x dx(3x^2+x^3-1)=e^x(x^3-1)+\mathrm{C}.$$

145. In other cases we may have recourse to the method of integration by parts (art. 134). Thus, let the differential be $x^n a^x dx$, then, by the formula $\int udv = uv - \int vdu$, making $u = x^n$, $dv = a^x dx$, we find

$$\int a^x x^n dx=\frac{a^x x^n}{\mathrm{l}.\,a}-\frac{n}{\mathrm{l}.\,a}\int a^x x^{n-1}dx.$$

By treating the differential $a^x x^{n-1}dx$ in the same way, and repeating this as often as necessary, we find $\int a^x x^n dx =$

$$a^x\left\{\frac{x^n}{\mathrm{l}.\,a}-\frac{nx^{n-1}}{(\mathrm{l}.\,a)^2}+\frac{n(n-1)x^{n-2}}{(\mathrm{l}.\,a)^3}-\ldots\pm\frac{1.2.3\ldots n}{(\mathrm{l}.\,a)^{n+1}}\right\}+\mathrm{C}.$$

146. If the exponent n be negative, by following the same method we may increase the exponent of x. Accordingly, from the formula $\int udv = uv - \int vdu$, making $u = a^x$, and $dv = \dfrac{dx}{x^n}$, we find

$$\int\frac{a^x dx}{x^n}=\frac{-a^x}{(n-1)x^{n-1}}+\frac{\mathrm{l}.\,a}{n-1}\int\frac{a^x dx}{x^{n-1}}.$$

By repeating this transformation, we bring the integral $\int\dfrac{a^x dx}{x^n}$ to depend at last on $\int\dfrac{a^x dx}{x}$.

If we make $a^x = z$, then $x\,\mathrm{l}.\,a = \mathrm{l}.\,z$, and $x = \dfrac{\mathrm{l}.\,z}{\mathrm{l}.\,a}$, and $dx = \dfrac{1}{\mathrm{l}.\,a}\dfrac{dz}{z}$; hence $\dfrac{a^x dx}{x} = \dfrac{1}{\mathrm{l}.\,a}\dfrac{dz}{\mathrm{l}.\,z}$, and

$$\int\frac{a^x dx}{x}=\frac{1}{\mathrm{l}.\,a}\int\frac{dz}{\mathrm{l}.\,z}.$$

These two integrals involve the same difficulty, and have greatly exercised the ingenuity of analysts. It appears they can only be integrated by infinite series. See on this subject, Lacroix, *Traité du Calcul Differentiel*, vol. iii. No. 1224.

147. If n be a fraction, either of the preceding methods will apply to reduce the exponent of x to some fraction between 0 and $+ 1$ or $- 1$; and then recourse must be had to the method of infinite series.

Whatever has been done in regard to the integral of $x^n a^x dx$, will apply to $\mathrm{P}a^x dx$, supposing P to be any function of x whatever.

Integration of Angular or Circular Functions.

148. There are several ways of integrating expressions which contain circular or trigonometrical functions of a variable.

Method I.—Let x be an arc whose sine or cosine is z; for example, let $\sin x = z$, then

$$\cos x = \sqrt{1-z^2},\ dx=\frac{dz}{\sqrt{1-z^2}},$$

$$dx\,\sin^m x\,\cos^n x = z^m(1-z^2)^{\frac{n-1}{2}}dz.$$

1. If n be any odd number, then, in the binomial differential, the radical in the transformed expression disappears.

2. If m is an odd number, the exponent of z without the parenthesis, when increased by unity, will be a multiple of z its exponent, within the parenthesis. Thus one of the conditions of art. 133 is satisfied, and the differential may be made rational.

3. If m and n are even numbers, then the second condition of art. 133 will be satisfied, and the differential may be integrated.

As an example, let the differential be $dx \sin^3 x$. This, by making $z = \sin x$, becomes $\frac{z^3\,dz}{\sqrt{1-z^2}}$. Now, by art. 137,

$$\int \frac{z^3\,dz}{\sqrt{1-z^2}} = -\tfrac{1}{3}\cos x\,(2+\sin^2 x) + C.$$

149. Method II.—The powers of the sine or cosine may be transformed into series, of which the terms are sines or cosines of the multiples of the arc; the terms to be integrated will then have the form $dx \cos kx$, $dx \sin kx$. Now

$$\int dx \cos kx = \frac{1}{k}\sin kx + C;$$

$$\int dx \sin kx = -\frac{1}{k}\cos kx + C.$$

Ex. 1. Let the differential be $dx \cos^5 x$. By the calculus of sines (Algebra, 258), $\cos^5 x = \frac{1}{16}(\cos 5x + 5 \cos 3x + 10 \cos x)$; therefore

$\int dx \cos^5 x = \frac{1}{80}\sin 5x + \frac{5}{48}\sin 3x + \frac{5}{8}\sin x + C.$

This method is often used, because the sines and cosines of the multiples of an arc are more easily found than the powers of the sine and cosine.

Ex. 2. Let the differential be $dx \cos^2 x \sin^3 x$. In the first place, we have (Algebra, art. 260),

$\cos^2 x \sin^3 x = \frac{1}{16}(-\sin 5x + \sin 3x + 2\sin x).$

Hence, multiplying by dx, and integrating,

$\int dx \cos^2 x \sin^3 x = \frac{1}{80}\cos 5x - \frac{1}{48}\cos 3x - \frac{1}{8}\cos x + C.$

150. Method III.—It has been found (Algebra, art. 270), that e being the base of Napier's logarithms,

$$\cos x = \frac{e^{x\sqrt{-1}} + e^{-x\sqrt{-1}}}{2};$$

$$\sin x = \frac{e^{x\sqrt{-1}} - e^{x\sqrt{-1}}}{2\sqrt{-1}}.$$

These exponential expressions for the sine and cosine enable us to transform differentials containing circular functions into others involving exponential and logarithmic functions, and to integrate by the methods explained (art. 140–145).

151. Method IV.—We may reduce the integration of such a differential as $\sin^m x \cos^n x\,dx$, to that of another in which the indices of the sine or cosine are smaller numbers, by the formula $\int u\,dv = uv - \int v\,du$. For, making $u = \sin^{m-1} x$ and $dv = dx \sin x \cos^n x$, we find $v = -\frac{\cos^{n+1} x}{n+1}$, and

$$\int dx \sin^m x \cos^n x = -\frac{\sin^{m-1}}{n+1}x\cos^{n+1} x + \frac{m-1}{n+1}\int dx \cos^{n+2} x \sin^{m-2} x.$$

From this expression, by putting for $\cos^{n+2} x$, its value $\cos^n x\,(1-\sin^2 x)$, and transposing, we find

(α)

$$\int dx \sin^m x \cos^n x = -\frac{\sin^{m-1} x \cos^{n+1} x}{m+n} + \frac{m-1}{m+n}\int dx \sin^{m-2} x \cos^n x.$$

By resolving the proposed differential into the two factors $dx \cos x \sin^m x$ and $\cos^{n-1} x$, and proceeding in the same way, we find

(β)

$$\int dx \sin^m x \cos^n x = \frac{\sin^{m+1} x \cos^{n-1} x}{m+n} + \frac{n-1}{m+n}\int dx \sin^m x \cos^{n-2} x.$$

One of these formulæ serves to depress the exponent of the sine, and the other that of the cosine, and by their joint application the differential may be found when m and n are two positive integer numbers. For example,

$\int dx \sin^3 x \cos^2 x = -\frac{1}{5}\sin^2 x \cos^3 x + \frac{2}{5}\int dx \sin x \cos^2 x,$

$\int dx \sin x \cos^2 x = \frac{1}{3}\sin^2 x \cos x + \frac{1}{3}\int dx \sin x;$

this last term $= -\frac{1}{3}\cos x + C$, after collecting the terms, we have $\int dx \sin^3 x \cos^2 x =$

$\cos x\,(-\frac{1}{5}\sin^2 x \cos^2 x + \frac{2}{15}\sin^2 x - \frac{2}{45}) + C.$

152. When m and n are negative, these formulæ require some modification. The first, by changing n into $-n$, gives

(γ)

$$\int \frac{dx \sin^m x}{\cos^n x} = -\frac{\sin^{m-1} x}{(m-n)\cos^{n-1} x} + \frac{m-1}{m-n}\int \frac{dx \sin^{m-2} x}{\cos^n x}.$$

This makes the integral sought depend on that of $\frac{dx \sin x}{\cos^n x}$ or $\frac{dx}{\cos^n x}$, according as m is odd or even. By making $\cos x = z$, the first of these becomes $-\frac{dz}{z^n}$, of which the integral is obvious. The integral of the other will be shown presently in art. 153.

The second of the two general formulæ, by making n negative, and bringing the integral in the second side of the equation to stand alone, and lastly, changing n into $n-2$, gives

(δ)

$$\int \frac{dx \sin^m x}{\cos^n x} = \frac{\sin^{m+1} x}{(n-1)\cos^{n-1} x} - \frac{m-n+2}{n-1}\int \frac{dx \sin^m x}{\cos^{n-2} x}.$$

By this the integral sought is reduced to that of $dx \sin^m x$, or to $\frac{dx \sin^m x}{\cos x}$, according as n is even or odd. The first is found by formula (α) (art. 151), the other is presently to be noticed.

153. If we make m or $n = 0$, we have

$$\int dx \sin^m x = \frac{-\cos x \sin^{m-1} x}{m} + \frac{m-1}{m}\int dx \sin^{m-2} x,$$

$$\int dx \cos^n x = \frac{\sin x \cos^{n-1} x}{n} + \frac{n-1}{n}\int dx \cos^{n-2} x,$$

$$\int \frac{dx}{\sin^m x} = \frac{-\cos x}{(m-1)\sin^{m-1} x} + \frac{m-2}{m-1}\int \frac{dx}{\sin^{m-2} x}$$

$$\int \frac{dx}{\cos^n x} = \frac{\sin x}{(n-1)\cos^{n-1} x} + \frac{n-2}{n-1}\int \frac{dx}{\cos^{n-2} x}.$$

154. When the exponents of the sine and cosine are both negative, we multiply the numerator by $\cos^2 x + \sin^2 x = 1$, and have

$$\int\frac{dx}{\sin^m x\cos^n x}=\int\frac{dx}{\sin^{m-2}x\cos^n x}+\int\frac{dx}{\sin^m x\cos^{n-2}x},$$
fractions with $\sin x$ or $\cos x$ in the denominator.

If $m=n$, then because $\sin x\cos x=\frac{1}{2}\sin 2x$, by making $2x=z$, the fraction takes the form of the third of the preceding formulæ.

155. We shall conclude this branch of the subject by integrating four of the more elementary circular functions.

1. To integrate $\frac{dx}{\sin x}$. We observe that $\sin x=2\sin\frac{1}{2}x\cos\frac{1}{2}x$, therefore,
$$\frac{dx}{\sin x}=\frac{dx}{2\sin\frac{1}{2}x\cos\frac{1}{2}x}=\frac{1}{2}\frac{dx\sec^2\frac{1}{2}x}{\tan\frac{1}{2}x}=\frac{d.\tan\frac{1}{2}x}{\tan\frac{1}{2}x},$$
$$\text{and }\int\frac{dx}{\sin x}=\text{l. }(\tan\tfrac{1}{2}x)+\text{C}.$$

2. To integrate $\frac{dx}{\cos x}$. Putting $\frac{1}{2}\pi$ to denote an arc of $90°$, and $x=\frac{1}{2}\pi-z$, we have $dx=-dz$, $\cos x=\sin z$, and
$$\int\frac{dx}{\cos x}=\int\frac{-dz}{\sin z}=-\text{l.}\tan\tfrac{1}{2}z=\text{l.}\frac{1}{\tan\frac{1}{2}z}+\text{C}.$$
$$\text{Now }\frac{1}{\tan\frac{1}{2}z}=\frac{1}{\tan(\frac{1}{4}\pi-\frac{1}{2}x)}=\tan(\tfrac{1}{4}\pi+\tfrac{1}{2}x).$$
$$\text{Therefore }\int\frac{dx}{\cos x}=\text{l. }\tan(\tfrac{1}{4}\pi+\tfrac{1}{2}x)+\text{C}.$$
This and the preceding integral may be otherwise expressed thus,
$$\int\frac{dx}{\sin x}=\tfrac{1}{2}\text{l.}\frac{1-\cos x}{1+\cos x}+\text{C}.$$
$$\int\frac{dx}{\cos x}=\tfrac{1}{2}\text{l.}\frac{1+\sin x}{1-\sin x}+\text{C}.$$
$$3.\ \int\frac{dx}{\tan x}=\int\frac{dx\cos x}{\sin x}=\text{l. }(\sin x)+\text{C}.$$
$$4.\ \int dx\tan x=\int\frac{dx\sin x}{\cos x}=\text{l.}\frac{1}{\cos x}+\text{C}.$$

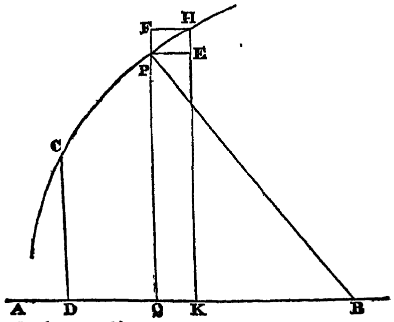
Applications of the Integral Calculus.

Before we proceed farther in the explanation of the theory of the calculus, we shall apply its principles to some of the more important problems in Geometry.

Quadrature of Curves.

156. Let $\text{AQ}=x$, $\text{PQ}=y$, be the co-ordinates of a curve, of which AB is the axis; and let the area CDQP, comprehended between CD, an ordinate given in position, and PQ any other ordinate, be denoted by s. We

Fig. 21.



have found (art. 69) that $ds=ydx$; therefore, in any curve whatever,
$$\text{area } s=\int ydx$$

Ex. 1. Let the curve be a parabola, of which p is the parameter. By the nature of the curve, $y^2=px$, and $y=p^{\frac{1}{2}}x^{\frac{1}{2}}$, and $ydx=p^{\frac{1}{2}}x^{\frac{1}{2}}dx$; therefore, taking the integral by art. 104,
$$s=\int ydx=\tfrac{2}{3}p^{\frac{1}{2}}x^{\frac{3}{2}}+c=\tfrac{2}{3}yx+\text{C}.........(1)$$
Let $\text{AD}=a$, $\text{CD}=b$; when $s=0$, then $x=a$, $y=b$. These values being substituted in the above general expression for the area, it becomes
$$0=\tfrac{2}{3}ab+\text{C}.$$
If we now subtract the sides of equation (2) from the corresponding sides of (1), the indeterminate constant C will disappear, and we shall have
$$s=\tfrac{2}{3}(xy-ab).$$
This is a convenient way of eliminating the indeterminate constant. If A, the origin of the abscissa x, be the vertex of the parabola, and if the area s be supposed to begin at the vertex, then $a=0$, $b=0$; and the area comprehended between the axis, an ordinate, and the curve, is $\frac{2}{3}xy$, that is, $\frac{2}{3}$ of the circumscribing parallelogram.

Ex. 2. Let the curve be a circle Apa (see fig. 7, art. 66), of which Aa is a diameter. Suppose the origin of co-ordinates to be at O, the centre; let Ob be the radius perpendicular to OA; put $\text{OQ}=x$, $p\text{Q}=y$, OA the radius $=a$, the space $\text{OQ}pb=s$; by the nature of the circle $x^2+y^2=a^2$, and $y=\sqrt{a^2-x^2}$; hence
$$s=\int ydx=\int dx\sqrt{a^2-x^2}.$$
This integral cannot be expressed in finite algebraic terms; therefore recourse must be had to an infinite series. By the binomial theorem, $\sqrt{a^2-x^2}=(a^2-x^2)^{\frac{1}{2}}=$
$$a-\frac{1\,.\,x^2}{2\,.\,a}-\frac{1\,.\,1\,.\,x^4}{2\,.\,4\,a^3}-\frac{1\,.\,1\,.\,3\,.\,x^6}{2\,.\,4\,.\,6\,a^5}-\text{\&c.}$$
Each term of this series being multiplied by dx, and the integral taken, we have
$$s=ax-\tfrac{1}{2}\cdot\frac{x^3}{3a}-\frac{1.1}{2.4}\cdot\frac{x^5}{5a^3}-\frac{1.1.3}{2.4.6}\cdot\frac{x^7}{7a^5}-\text{\&c.}+\text{C}.$$
To determine C, we consider that when $x=0$, then $s=0$, these values make both sides of the equation $=0$; therefore $\text{C}=0$; when $x=a$, then $s=\frac{1}{4}$ of the area of the circle; therefore the area of a circle whose radius $=a$ is
$$4a^2\left(\frac{1}{1}-\frac{1}{2}\cdot\frac{1}{3}-\frac{1.1}{2.4}\cdot\frac{1}{5}-\frac{1.1.3}{2.4.6}\cdot\frac{1}{7}-\text{\&c.}\right).$$
This series converges slowly, so that a considerable number of terms would be required to give its value near the truth. If we make $x=\cos$ arc $60°$, then, drawing the radius Op, the area OQpb will manifestly be made up of the sector POb, which is $\frac{1}{12}$ of the area of the circle, and the triangle OQp, which is $\frac{1}{2}\text{OQ}\,.\,p\text{Q}=\frac{\sqrt{3}}{8}a^2$.

Putting $\frac{a}{2}$ for x in the series, it will now converge much faster, and the sum of seven of its terms will be $\cdot4783057a^2$, from which subtracting $\frac{\sqrt{3}}{8}a^2=\cdot2165063a^2$, there remains $\cdot2617994a^2$ for $\frac{1}{12}$ of the area, and $3\cdot1415928a^2$ for the whole area of the circle. We have found this number by a less laborious calculation, in ALGEBRA, 273. We may make A, one end of the diameter (fig. 7, art. 66), the origin of the co-ordinates, so that $\text{AQ}=x$, $pq=y$, segment $\text{A}p\text{Q}=s$ · then, because $y=\sqrt{2ax-x^2}$, the area
$$s=\int dx\sqrt{2ax-x^2}=\int dx\sqrt{2ax}\left(1-\frac{x}{2a}\right)^{\frac{1}{2}}.$$
The integral of this expression will be had by convert-

ing $\left(1-\frac{x}{2a}\right)^{\frac{1}{2}}$ into a series, then multiplying the terms separately by $dx\sqrt{2ax}$, and integrating.

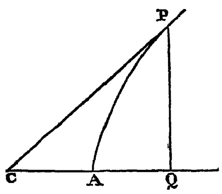
Ex. 3. To find the area of the elliptic segment APQ (fig. 7, art. 66). Let OA, the semitransverse, $=a$, OB, the semiconjugate, $=b$, AQ$=x$, PQ$=y$, the area APQ$=s$. By the nature of the ellipse, $y=\frac{b}{a}\sqrt{2ax-x^2}$; therefore the elliptic segment

$$s=\int ydx=\frac{b}{a}\int dx\sqrt{2ax-x^2}.$$

Let AP*a* be a semicircle on the same axis, and let s' denote the segment cut off by the ordinate *p*PQ, which is common to both curves. We found in last example that $s'=\int dx\sqrt{2ax-x^2}$; therefore $s=\frac{b}{a}s'$. Thus it appears that the area of APQ, any segment of an ellipse, has to the area of A*p*Q the corresponding segment of the circumscribing circle, the constant ratio of the lesser axis to the greater. Neither of the integrals require a constant, because both vanish when $x=0$.

Ex. 4. To find the area of the hyperbolic sector PCA, C being the centre of the hyperbola, and CA the semitransverse axis.

Fig. 22.



Draw the ordinate PQ; let the semitransverse axis CA $=a$, the semiconjugate axis $=b$, CQ $=x$, PQ $=y$, the sector PAC $=s$.
Because $s=$ triangle CPQ — space APQ $=\frac{1}{2}xy-\int ydx$; therefore $ds=\frac{1}{2}xdy+\frac{1}{2}ydx-ydx=\frac{1}{2}(xdy-ydx)$.

Now, by the nature of the curve, $y=\frac{b}{a}\sqrt{x^2-a^2}$, therefore $dy=\frac{b}{a}\frac{xdx}{\sqrt{x^2-a^2}}$, and

$$ds=\frac{b}{2a}\left\{\frac{x^2dx}{\sqrt{x^2-a^2}}-dx\sqrt{x^2-a^2}\right\}=\frac{1}{2}ab\frac{dx}{\sqrt{x^2-a^2}}.$$

Now, by art. 125, $\int\frac{dx}{\sqrt{x^2-a^2}}=\text{l.}\,(x+\sqrt{x^2-a^2})+\text{C}.$

$$\text{Therefore } s=\frac{ab}{2}\,\text{l.}\,(x+\sqrt{x^2-a^2})+\text{C}.$$

Here C denotes an indefinite constant: To determine its value, we consider that when $x=a$, then $s=0$; therefore in this particular case,

$$0=\frac{ab}{2}\,\text{l.}\,a+\text{C}.$$

Hence, by subtracting equals from equals, and observing that the difference of two logarithms is the logarithm of their quotient, we eliminate C, and have

$$s=\frac{ab}{2}\,\text{l.}\,\frac{x+\sqrt{x^2-a^2}}{a}.$$

Because $\sqrt{x^2-a^2}=\frac{ay}{b}$, therefore also

$$s=\frac{ab}{2}\,\text{l.}\,\left\{\frac{x}{a}+\frac{y}{b}\right\}.$$

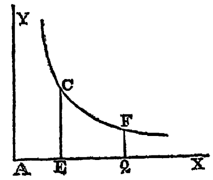
Ex. 5. To find the area of s, the hyperbolic space APQ, we have $s=$ triangle CPQ — sector CAP, or

$$s=\frac{1}{2}xy-\frac{ab}{2}\,\text{l.}\,\left\{\frac{x}{a}+\frac{y}{b}\right\}.$$

Ex. 6. Let the curve be an equilateral hyperbola, of which AX, AY are the asymptotes: To find s, the area included by the hyperbolic arc CF, the straight lines CE, FQ, which are parallel to one asymptote, and EQ, the segment of the other asymptote between them; suppose CE one of the parallels to be given in position. Put AE $=a$, EC $=b$, AQ $=x$, EQ$=y$. By the nature of the curve, $xy=ab$; hence $y=\frac{ab}{x}$, and

$$s=\int ydx=ab\int\frac{dx}{x}=ab\,\text{l.}\,x+\text{C}.$$

Fig. 23.



Now, when $x=a$, then $s=0$; in this case $0=ab\,\text{l.}\,a+\text{C}$, or $\text{C}=-ab\,\text{l.}\,a$; hence, substituting for C its value, and putting $\text{l.}\,\frac{x}{a}$ for $\text{l.}\,x-\text{l.}\,a$, we have

$$s=ab\,\text{l.}\,\frac{x}{a}.$$

From this formula we find $\text{l.}\,\frac{x}{a}=\frac{s}{ab}$. Thus it appears that Napier's logarithm of any number $\frac{x}{a}$ may be expressed by a hyperbolic area; hence it has happened that the logarithms of his system have been called *hyperbolic*.

If M be the *modulus* of any system, the log of $\frac{x}{a}$ in that system will be M $\text{l.}\,\frac{x}{a}$; therefore, in any system of which the modulus is M, we have

$$\log.\,\frac{x}{a}=\frac{\text{M}}{ab}s.$$

Thus we see that logarithms of any system may be expressed geometrically by hyperbolic areas, and therefore that the name *hyperbolic logarithms* cannot with propriety be given to one kind of logarithms rather than to another.

Ex. 7. Let the curve be the cycloid (fig. 9, art. 66), of which AC is the axis, and AH a perpendicular to the axis at the vertex A. From any point in the curve draw PG perpendicular to AH: it is proposed to find s, the area of the external space contained by the straight lines AG, GP, and the cycloidal arc AP.

Let O be the centre of the generating circle; draw PDQ perpendicular to AC, meeting the circle in D, and join OD. Put $x=$ AG, $y=$ PG, $a=$ AO, $v=$ angle AOD; then (art. 66) PQ $=a(v+\sin v)$, AQ $=a(1-\cos v)$, therefore,
$x=a(v+\sin v)$, $y=a(1-\cos v)$, $dx=adv(1+\cos v)$,
$ds=a^2(1-\cos v)(1+\cos v)dv=a^2dv\sin^2 v$,
and integrating by 153,

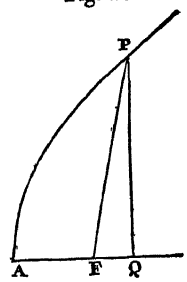
$$s=a^2\int dv\sin^2 v=\frac{a^2}{2}(v-\sin v\cos v)+\text{C}.$$

When $v=0$, then s ought to vanish; this requires that $\text{C}=0$. Putting now the arc AD for av, and DQ · OQ for $a^2\sin v\cos v$, we have
$s=\frac{1}{2}$ AO · arc AD — $\frac{1}{2}$ DQ · OQ $=$ circ. seg. ADQ.

Inverse Method.

Ex. 8. To find the area contained by AF, a line drawn from the focus of a parabola to the vertex, FP a line drawn to any point of the curve, and the intercepted arc AP.

Fig. 24.



Let a denote the parameter $=4$AF, $u=$ the angle AFP, $r=$ FP, $s=$ the parabolic sector APF. Draw PQ perpendicular to the axis AF. By the nature of the curve, PF $=$ AQ$+$AF. Now, supposing PFA to be an obtuse angle, FQ $=-r\cos v$, AQ $=\frac{1}{4}a-r\cos v$, AF $=\frac{1}{4}a$, therefore, $r=\frac{1}{2}a-r\cos v$, and $r(1+\cos v)=\frac{1}{2}a$; hence, since $1+\cos v=2\cos^2\frac{1}{2}v$, $r=\dfrac{a}{4}\dfrac{1}{\cos^2\frac{1}{2}v}$.

Now, by formula 3, article 70, $ds=\frac{1}{2}r^2dv$, therefore

$$ds=\frac{a^2}{16}\frac{\frac{1}{2}dv}{\cos^4\frac{1}{2}v}.$$

To integrate this differential, we consider that

$$\frac{\frac{1}{2}dv}{\cos^2\frac{1}{2}v}=\sec^2\tfrac{1}{2}v\frac{dv}{2}=d(\tan\tfrac{1}{2}v);$$

and that $\dfrac{1}{\cos^2\frac{1}{2}v}=\sec^2\frac{1}{2}v=1+\tan^2\frac{1}{2}v$;

therefore, multiplying these equations, we get

$$\frac{\frac{1}{2}dv}{\cos^4\frac{1}{2}v}=d(\tan\tfrac{1}{2}v)+\tan^2\tfrac{1}{2}v\,d(\tan\tfrac{1}{2}v);$$

and hence, integrating by the rule art. 104, we find

$$\int\frac{\frac{1}{2}dv}{\cos^4\frac{1}{2}v}=\tan\tfrac{1}{2}v+\tfrac{1}{3}\tan^3\tfrac{1}{2}v+\text{C}.$$

Observing now that when $v=0$, then $s=0$; therefore C $=0$, and we have

$$s=\frac{a^2}{16}(\tan\tfrac{1}{2}v+\tfrac{1}{3}\tan^3\tfrac{1}{2}v).$$

This integral might have been found by the formula of art. 153; not so easily, however. The formula here found is wanted in the astronomy of comets.

157. Since the area of any plane curve is expressed by an integral $\int ydx$, in which y the ordinate is some function of x the absciss, so, on the other hand, any integral may be represented geometrically by the area of a curve. The geometrical representation of an integral shows distinctly wherein it differs from a common analytic function, such as $a+bx^n$, or ax, or $\sin x$, &c. These last have determinate values corresponding to any given value of x, and each is independent of its preceding and following values; but the magnitude of the space represented by an integral $\int ydx$ is the increment that a certain area receives while the variable x passes from one state of magnitude to another. Thus the absolute magnitude of the space CDQP (fig. 11), which represents an integral $\int ydx$, and which, when the curve is a parabola, is expressed by $\frac{2}{3}xy+$C, cannot be known before C is determined, or else eliminated from the expression.

Whatever be the nature of the curve, the integral $\int ydx=$ space CPQD is correctly indicated, so as to admit of being computed, when we say that it is generated while the variable x increases from any value $=$ AD, to another value $=$ AQ, the lines AD, AQ being supposed given in magnitude, and the relation between x and y known. The same thing is briefly indicated by this notation:

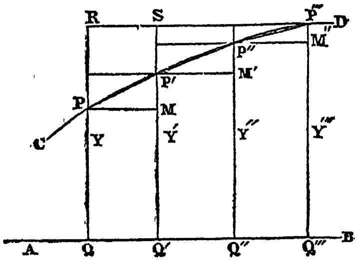
$$\text{area CPQD}=\int_a^x ydx,$$

in which a and x denote the lines AD and AQ.

From what has been shown it appears that an integral is an indeterminate quantity, the result of a change in the value of its variable; and that to know its absolute value we must know the values of the variable at its commencement and completion.

158. The analogy between a curvilineal area and an integral indicates a general method of finding its numerical value to any degree of nearness. Supposing y to be any function of x, let it be proposed to find the integral $\int ydx$ between $x=a$ and $x=b$.

Fig. 25.



Let CPD be a curve, of which the co-ordinates are x and y. In the axis AB, take AQ $=a$, the least value of x, and AQ‴ $=b$, its greatest value, and draw the ordinates PQ, P‴Q‴. The area PQQ‴P‴ will be the geometrical expression of the integral between the proposed limits; and by whatever means that area can be found, the same will apply to the determination of the integral.

Divide QQ‴ into any number of equal parts at the points Q′, Q″, &c. and draw the ordinates P′Q′, P″Q″, &c. These will divide the whole figure into the spaces PP′Q′Q, P′P″Q″Q′, &c. Let a series of rectangles PQ′, P′Q″, P″Q‴ be formed, each having the least of two adjoining ordinates for a side: these will fall within the curve, supposing it to be entirely concave or convex towards the axis. Let another series P′Q, P″Q′, P‴Q″ be constructed, each having the longest of two adjoining ordinates for a side: the aggregate of these will exceed the area of the curve. The length of the base of each rectangle will be known, and, from the nature of the curve, its height will also be known; hence the areas of all the rectangles may be found. The sum of the areas of the inscribed rectangles will be less than the integral, and the sum of the areas of the circumscribing rectangles will be greater. The difference between these sums is the rectangle PMSR, which, by supposing its base PM $=$ QQ′ to be sufficiently small, may be less than any assignable space. Thus an approximate value of the integral may be found, which shall differ from the truth by as small a quantity as we please.

Draw the chords PP′, P′P″, P″P‴, thus forming a series of trapeziums, which will differ from the curvilineal area by less than the sum of either the inscribed or circumscribing parallelograms, and will be a mean between them. This will be a nearer approximation than either sum to the integral.

As an example of the application of this method, let it be proposed to approximate to the integral $\int_0^1\dfrac{dx}{1+x^2}$, that is, to the arc whose tangent is x, between the values of $x=0$ and $x=1$, which arc is $\dfrac{1}{4}$ of a semicircle, the radius

being supposed $= 1$. In this case the equation of the curve is $y = \frac{1}{1+x^2}$. Let us suppose the base QQ‴ to be divided into ten equal parts; then, making $x = 0$, $x = \cdot 1$, $x = \cdot 2$, &c. to $x = 1$, we obtain eleven equidistant ordinates or values of y as follows:

The 1*st*,	1.00000	The 7*th*,	·73529
2*d*,	·99010	8*th*,	·67114
3*d*,	·96154	9*th*,	·60975
4*th*,	·91743	10*th*,	·55249
5*th*,	·86207	11*th*,	·50000
6*th*,	·80000		

By the elements of geometry, the area of the rectilineal figure formed by the trapeziums is found by adding together all the ordinates except the first and last, and half the sum of the first and last, and multiplying the result by the common breadth of the trapeziums, which is ·1. This gives ·784981 for the area or value of the integral $\int_0^1 \frac{dx}{1+x^2}$. The true value expressed by a series is $1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} +$ &c. which converges too slowly to be of any practical use: by other methods the more correct value of the integral is ·7854 nearly.

159. Supposing the ordinates PQ, P′Q′, &c. to go on continually increasing, the inscribed rectangles will be constructed on the 1st, 2d, 3d, &c. ordinates, and the circumscribing rectangles on the 2d, 4th, 6th, &c.

Observing now that the ordinates are the values of y corresponding to AQ, AQ′, &c. values of x, which differ by the common interval QQ′, we have manifestly the following rule for approximating to an integral $\int ydx$ between the limits of $x = \mathrm{AQ} = a$ and $x = \mathrm{AQ}''' = b$. Divide the interval $\mathrm{QQ}''' = b - a$ into n equal parts, each equal to h.

Find Y, Y′, Y″, ... $\mathrm{Y}^{(n)}$ the particular values of Y corresponding to $x = a$, $x = a + h$, $x = a + 2h$ .... $x = a + nh = b$.

Then, supposing the ordinates to go on increasing,

$$\int_a^b ydx > h\,(\mathrm{Y} + \mathrm{Y}' + \mathrm{Y}'' \ldots . + \mathrm{Y}^{(n-1)});$$

$$\int_a^b ydx < h\,(\mathrm{Y}' + \mathrm{Y}'' + \mathrm{Y}''' \ldots . + \mathrm{Y}^{(n)}).$$

The difference of these is $h(\mathrm{Y}^{(n)} - \mathrm{Y})$, which, by taking h sufficiently small, may be as small as we please. We may reason in the same way when the ordinates form a decreasing series. If they first increase and then decrease, the interval $b - a$ may be divided into two or more portions, such that y increases or decreases continually from one end of each to the other.

Whatever be the values of y, provided they be always finite from $x = a$ to $x = b$, putting for them Y, Y′, Y″ .. $\mathrm{Y}^{(n)}$, we have

$$\int_a^b ydx \,. = \mathrm{Y}h + \mathrm{Y}'h + \mathrm{Y}''h \ldots . + \mathrm{Y}^{n-1}\,h.$$

Leibnitz and his followers considered the integral $\int ydx$ as the sum of the infinitely little elements Yh, Y′h, &c. Hence the origin of the terms integral, to integrate, integration, &c. When h is infinitely little, and represented by dx, the differential of x, then ydx is the differential of the integral.

Rectification of Curves.

160. We have found (art. 72) that z being any arc of a curve referred to an axis by rectangular co-ordinates x, y, the differential of the arc, viz. $dz, = \sqrt{dx^2 + dy^2}$. We are now to apply the calculus to particular curves.

Ex. 1. Let the curve be a parabola (fig. 16) of which the parameter $= 2a$, the absciss $\mathrm{AQ} = x$, the ordinate $\mathrm{PQ} = y$. The equation of the curve, $2ax = y^2$, gives

$$adx = ydy \text{ and } dz = \sqrt{dx^2 + dy^2} = \frac{1}{a}dy\sqrt{a^2 + y^2}.$$

If in formula B, art. 135, we make $m = 1$, $n = 2$, $p = \frac{1}{2}$, $b = 1$, and put y instead of x, and a^2 instead of a, we have

$$\int dy\sqrt{a^2 + y^2} = \tfrac{1}{2}\,y\sqrt{a^2 + y^2} + \tfrac{1}{2}\,a^2\int\frac{dy}{\sqrt{a^2 + y^2}}.$$

The integral in the second side of this equation is, by the formula of art. 130, $\mathrm{l.}\,(y + \sqrt{a^2 + y^2}) + \mathrm{C}$; therefore $z = \frac{y}{2a}\sqrt{a^2 + y^2} + \frac{a}{2}\,\mathrm{l.}\,(y + \sqrt{a^2 + y^2}) + \mathrm{C}$.

If we suppose z to begin at the vertex, then, when $z = 0, y = 0$; therefore $\mathrm{C} = -\frac{a}{2}\,\mathrm{l.}\,a$, and

$$z = \frac{y}{2a}\sqrt{a^2 + y^2} + \frac{a}{2}\,\mathrm{l.}\,\frac{y + \sqrt{a^2 + y^2}}{a}.$$

Ex. 2. Let the curve be the second cubic parabola of which the equation is $y^3 = ax^2$. In this case the general formula gives

$$dz = dy\sqrt{1 + \frac{9y}{4a}} \text{ and } z = \tfrac{8}{27}\sqrt{\left(1 + \frac{9y}{4a}\right)^3} + \mathrm{C}.$$

This curve is perfectly rectifiable. Indeed it is the evolute of the parabola (art. 81, ex. 1).

Ex. 3. Let the curve be a circle (fig. 7), of which the radius $\mathrm{OA} = a$. Reckoning the co-ordinates from the centre, let $\mathrm{OQ} = x$, $p\mathrm{Q} = y$, $b\mathrm{P} = z$. The equation of the curve is $x^2 + y^2 = a^2$; hence $y = \sqrt{a^2 - x^2}$, $dy = -\frac{xdx}{\sqrt{a^2 - x^2}}$ and $dz = \frac{adx}{\sqrt{a^2 - x^2}}$. This integral cannot be otherwise expressed than by an infinite series. We have already found it (art. 139, ex. 4) on the supposition that the radius $= 1$; when the radius $= a$, we have only to put $\frac{x}{a}$ instead of x, thence we get

$$z = x + \frac{1}{2}\cdot\frac{x^3}{3a^2} + \frac{1.3}{2.4}\cdot\frac{x^5}{5a^4} + \frac{1.3.5}{2.4.6}\frac{x^7}{7a^6} + \&\text{c}.$$

There is no constant wanted; because, from the nature of the case, z and x begin together.

From this example, also from ex. 2, art. 156, and ex. 2, art. 139, it appears that the quadrature, also the rectification of the circle, is equivalent to the determination of any one of these integrals, $\int dx\sqrt{1 - x^2}$, $\int\frac{dx}{\sqrt{1 - x^2}}$, $\int\frac{dx}{1 + x^2}$, which is a problem in pure analysis, and which does not seem to admit of a solution in finite terms. The solution of that celebrated geometrical problem is therefore hopeless.

Ex. 4. Let the curve be an ellipse (fig. 7), of which the semitransverse axis $\mathrm{OA} = 1$, the semiconjugate $\mathrm{OB} = b$, the eccentricity, which is $\sqrt{1 - b^2}, = e$. Let O the centre be the origin of the co-ordinates $\mathrm{OQ} = x$, $\mathrm{PQ} = y$; and, reckoning the arc from the extremity of the lesser axis, let $\mathrm{BP} = z$. By the nature of the curve, $y = b\sqrt{1 - x^2}$, therefore $dy = \frac{-bxdx}{\sqrt{1 - x^2}}$, and

$$dz = \sqrt{dx^2 + dy^2} = \frac{dx\sqrt{1 - (1 - b^2)x^2}}{\sqrt{1 - x^2}} = \frac{dx\sqrt{1 - e^2x^2}}{\sqrt{1 - x^2}}.$$

The integral of this differential is of such a nature as not to admit of being expressed either by arcs of a circle or logarithms. Therefore it can only be expressed by infinite series.

By the binominal theorem $\sqrt{1-e^2x^2}=$

$$1-\tfrac{1}{2}e^2x^2-\frac{1.1}{2.4}e^4x^4-\frac{1.1.3}{2.4.6}e^6x^6-\frac{1.1.3.5}{2.4.6.8}e^8x^8-\text{\&c.}$$

The terms of this series must now be multiplied each by $\frac{dx}{\sqrt{1-x^2}}$, and the integrals found, and their sum will express the length of the arc z.

The integrals, leaving out the numeral co-efficients, will all have the form $\int\frac{x^{2n}dx}{\sqrt{1-x^2}}$; therefore they will be found by the second formula of article 137. Thus, putting φ for the arc whose sine is x, we have

$$\int\frac{dx}{\sqrt{1-x^2}}=\varphi,$$

$$\int\frac{x^2dx}{\sqrt{1-x^2}}=-\tfrac{1}{2}x\sqrt{1-x^2}+\tfrac{1}{2}\varphi,$$

$$\int\frac{x^4dx}{\sqrt{1-x^2}}=-\left(\tfrac{1}{4}x^3+\frac{1.3}{2.4}x\right)\sqrt{1-x^2}+\frac{1.3}{2.4}\varphi,$$

&c.

These integrals being multiplied by their respective coefficients, we have the elliptic arc $z=$

$$\varphi\left(1-\frac{1.1}{2.2}e^2-\frac{1.1.3}{2.2.4.4}e^4-\frac{1.1.3.3.5}{2.2.4.4.6.6}e^6-\text{\&c.}\right)$$
$$+\tfrac{1}{2}e^2(\tfrac{1}{2}x\sqrt{1-x^2})$$
$$+\frac{1.1}{2.4}e^4\left(\tfrac{1}{4}x^3+\frac{1.3}{2.4}x\right)\sqrt{1-x^2}$$
$$+\frac{1.1.3}{2.4.6}e^6\left(\tfrac{1}{6}x^5+\frac{1.3}{4.6}x^3+\frac{1.3.5}{2.4.6}x\right)\sqrt{1-x^2}$$
$$+\text{\&c.}$$

Here no constant is wanted, because the functions on both sides of $=$ vanish when $x=0$, as they should.

If we make $x=1$, then all the terms multiplied by $\sqrt{1-x^2}$ vanish; and as in this case $\varphi=$ a quadrant $=\frac{1}{2}\pi$, we get the elliptic quadrant AB $=$

$$\tfrac{1}{2}\pi\left(1-\frac{1.1}{2.2}e^2-\frac{1.1.3}{2.2.4.4}e^4-\frac{1.1.3.3.5}{2.2.4.4.6.6}e^6-\text{\&c.}\right)$$

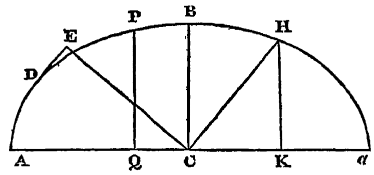
This expression converges pretty fast when e is small, but when e is nearly $=1$, it is hardly of any use. To have a complete solution, we ought to have another series suited to the case of $e=1$ nearly. Our limits, however, do not admit of our entering on its investigation here. The integration of the differential $\frac{dx\sqrt{1-e^2x^2}}{\sqrt{1-x^2}}$, which, putting φ for the arc whose sine $=x$, may be also expressed thus, $d\varphi\sqrt{1-e^2\sin^2\varphi}$, has greatly engaged the attention of mathematicians. On this subject consult the works quoted in the conclusion of our History of Fluxions, page 640.

The length of a hyperbolic arc may be found exactly in the same way as that of the ellipse from its equation $y=b\sqrt{x^2-1}$.

161. We shall here explain the remarkable property of the ellipse, first discovered by Fagnani, as has been mentioned, page 640, and which has proved the fertile germ of some of the finest discoveries in the modern analysis.

In the ellipse ABa, let DE be a tangent at any point D in the curve, draw CE from the centre perpendicular to the tangent, and parallel to it draw the semidiameter CH, which will be the conjugate to that drawn from C through D; and draw HK perpendicular to the axis. Let CA $=1$, CB $=b$, $\sqrt{1-b^2}$, the eccentricity, $=e$. Make the

Fig. 26.



perpendicular CE $=p$, the tangent DE $=t$, the angle ACE $=$ CHK $=\varphi$, and the arc AD $=z'$. By the nature of the ellipse, $CA^2\cdot HK^2=CB^2(CA^2-CK^2)$, that is, because HK $=$ CH cos φ, and CK $=$ CH sin φ, $CH^2\cos^2\varphi=b^2(1-CH^2\sin^2\varphi)$, and hence $b^2=CH^2(\cos^2\varphi+b^2\sin^2\varphi)=CH^2(1-e^2\sin^2\varphi)$, and $CH=\frac{b}{\sqrt{1-e^2\sin^2\varphi}}$.

Now, by the nature of the ellipse, $CH=\frac{CA\cdot CB}{CE}=\frac{b}{p}$, therefore $p=\sqrt{1-e^2\sin^2\varphi}$. Now it has been shown (art. 75) that in every curve $d(z+t)=pd\varphi$, and therefore $z+t=\int pd\varphi$; hence, in the ellipse, $z'+t=\int d\varphi\sqrt{1-e^2\sin^2\varphi}$.

In the semi-axis CA take CQ $=$ CA $\cdot$ sin ECA $=$ sin φ, draw the ordinate QP, and put $z=$ elliptic arc BP. By what was shown in last article, $dz=d\varphi\sqrt{1-e^2\sin^2\varphi}$, and $z=\int d\varphi\sqrt{1-e^2\sin^2\varphi}$; thence it appears that the functions $z'+t$ and z have the same differential, therefore they can only differ by a constant, that is, $z'+t=z+C$. Now when $z=0$, then $\varphi=0$, and $z'=0$, also $t=0$; therefore the variables z, z', and t' begin together, and the constant $C=0$; thus we have $z'+t=z$ and $z-z'=t$. Hence we have this very remarkable property of an ellipse. At any point D in the curve draw a tangent DE, and from the centre C draw CE perpendicular to the tangent. In CA take CQ $=$ CA $\cdot$ sin ECA; draw the ordinate PQ. *The difference of the elliptic arcs* BP, AD (*that is,* BP $-$ AD), *is equal to the tangent* DE. *This is in substance Fagnani's theorem. Hence it follows that any arc of an ellipse being given, another may be found by a geometrical construction, such, that their difference shall be an assignable straight line.*

We have found (art. 75) that in all curves $t=\frac{-dp}{d\varphi}$. In the ellipse $p=\sqrt{1-e^2\sin^2\varphi}$ and $\frac{dp}{d\varphi}=\frac{-e^2\sin\varphi\cos\varphi}{\sqrt{1-e^2\sin^2\varphi}}$. Therefore, without any reference to the length of the tangent,

$$z-z'=\frac{e^2\sin\varphi\cos\varphi}{\sqrt{1-e^2\sin^2\varphi}}.$$

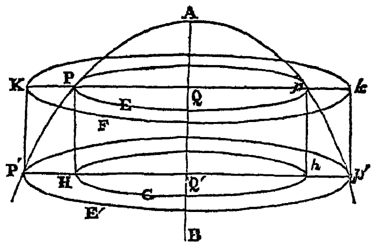
There are corresponding properties of the hyperbola, but our limits forbid our entering on them.

Cubature of Solids.

162. Let AB be the axis of any plane curve APP′, and PQ, P′Q′ ordinates perpendicular to the axis; draw PH perpendicular to the ordinate P′Q′, and P′K perpendicular to PQ. Conceive now the plane figure AP′Q′ to revolve about the axis AB; the curve AP will generate a solid AP′E′p', called a *solid of revolution;* and the rectangles

PQQ′H, P′Q′QK will generate cylinders whose bases are circles PEp, P′E′p', and common altitude QQ′.

Fig. 27.



Put AQ $= x$, AQ′ $= x'$, PQ $= y$, P′Q′ $= y'$; the solid generated by the space APQ $= s$, that generated by AP′Q′ $= s'$. Let $\pi = 3{\cdot}1416 =$ the area of a circle whose radius is 1. The content of the cylinder whose base is PEp will be $\pi(x'-x)y^2$, and that of the cylinder whose base is P′E′p' will be $\pi(x'-x)y'^2$.

The solid generated by the curvilineal space PQQ′P′ being greater than the cylinder whose base is PEp, but less than the cylinder whose base is P′E′p', we have

$$s'-s > \pi(x'-x)y^2, \text{ and } s'-s < \pi(x'-x)y'^2;$$

$$\text{therefore } \frac{s'-s}{x'-x} > \pi y^2, \text{ and } \frac{s'-s}{x'-x} < \pi y'^2.$$

Conceive now the circle P′E′p' to approach continually to the circle PEp; they will ultimately coincide and be equal; therefore πy^2 is the limit of $\frac{s'-s}{x'-x}$, and consequently $\frac{ds}{dx} = \pi y^2$, and

$$ds = \pi y^2 dx, \text{ and } s = \pi\textstyle\int y^2 dx.$$

By this formula the content of a solid of revolution generated by any given plane curve may be found.

163. Ex. 1. Let the solid be a paraboloid generated by the revolution of a parabola AP about its axis AQ. By the nature of the curve, $y^2 = ax$; therefore, in this case,

$$s = \pi\textstyle\int axdx = \frac{1}{2}\pi ax^2 + C = \frac{1}{2}\pi xy^2 + C.$$

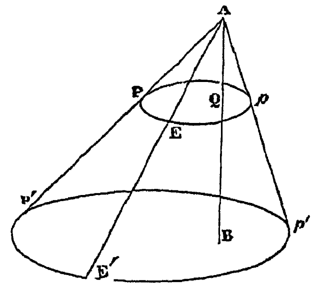
If the integral begin when $x = 0$, then also $s = 0$ and $C = 0$; now πxy^2 is the content of a cylinder having the same base as the paraboloid, therefore, *a paraboloid is half a cylinder of the same base and altitude.*

From this geometrical theorem we may find the content of the solid between two sections of a paraboloid by planes perpendicular to its axis, which is called a *frustum* of a paraboloid. Let A be the area of the base of the frustum, a the area of its top, h its height, x the segment of the axis between the vertex of the paraboloid and top of the frustum. The content of the whole paraboloid $= \frac{1}{2}(x+h)\text{A}$, and the content of the part cut off $= \frac{1}{2}xa$, therefore the content of the frustum $= \frac{1}{2}(x\text{A}+h\text{A}-xa)$. Now by the nature of the solid $\frac{x+h}{x} = \frac{\text{A}}{a}$, hence $x\text{A}-xa = ha$, therefore the content of the frustum is $\frac{1}{2}(\text{A}+a)h$. Hence it appears that a frustum of a paraboloid is equal to a cylinder of the same altitude, and whose base is a mean between the top and bottom of the frustum.

Ex. 2. Let the solid be a cone whose vertex is A, and base P′Ep', a plane figure of any kind.

Let AB be the altitude of the cone, and PEp a section parallel to the base, meeting AB in Q. Let $b =$ the area of the base P′Ep', $v =$ area of section PEp, $c =$ AB, $x =$ AQ, $s =$ content of solid A-PEp. In this case, $ds = vdx$, an expression the same as for a solid of revolution, and found in the same way. Now, sections of similar cones are proportional to the squares of their like

Fig. 28.

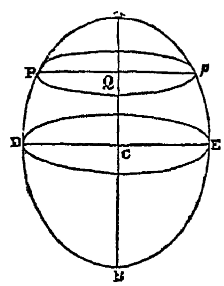


dimensions; therefore $c^2 : x^2 = b : v$, hence $v = \frac{bx^2}{c^2}$ and $ds = \frac{b}{c^2}x^2dx$, and by integration $s = \frac{bx^3}{3c^2} + C = \frac{vx}{3} + C$. If x and s begin together, then $C = 0$ and $s = \frac{1}{3}vx$. Thus it appears that *a cone of any kind is $\frac{1}{3}$ of its circumscribing cylinder.*

To find the content of a frustum of a cone, or space between the base and a plane parallel to its base; put A $=$ area of base, $a =$ area of top, $h =$ height of frustum, $x =$ height of cone cut off above the frustum. The content of the whole cone $= \frac{1}{3}(h+x)\text{A}$, and the content of the part cut off $= \frac{1}{3}xa$, therefore the content of the frustum $= \frac{1}{3}(h\text{A}+x\text{A}-xa) = \frac{1}{3}h\text{A} + \frac{1}{3}x(\text{A}-a)$. Now $\frac{\text{A}}{a} = \frac{(x+h)^2}{x^2}$, and $\frac{\sqrt{\text{A}}}{\sqrt{a}} = \frac{x+h}{x}$ hence $x = \frac{\sqrt{a}}{\sqrt{\text{A}}-\sqrt{a}}h$, and $x(\text{A}-a) = \sqrt{a}(\sqrt{\text{A}}+\sqrt{a})h = (\sqrt{\text{A}a}+a)h$. On the whole, the content of the frustum $= \frac{1}{3}(\text{A}+a+\sqrt{\text{A}a})h$.

Ex. 3. To find the content of a spheroid generated by the revolution of an ellipse about either of its axes.

Fig. 29.



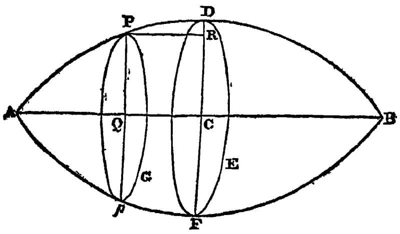
Let PQp be a section of the solid perpendicular to the fixed axis AB. Put AB $= a$, the revolving axis DE $= b$, also AQ $= x$, PQ $= y$. From the nature of the ellipse, $y^2 = \frac{b^2}{a^2}(ax-x^2)$, hence $s = \frac{\pi b^2}{a^2}\int(ax-x^2)dx = \frac{\pi b^2}{a^2}(\frac{1}{2}ax^2 - \frac{1}{3}x^3) + C$.

If we suppose $s = 0$ when $x = 0$, then $C = 0$. If we make $x = a$, then s, the whole spheroid, $= \frac{ab^2\pi}{6} = \frac{2}{3}a \times$ area of middle section. Hence it appears that *the whole solid is $\frac{2}{3}$ of its circumscribing cylinder.* This proposition was discovered by Archimedes.

If the axes a, b, be supposed equal, the solid is a sphere; hence it appears that the content of a sphere $= \frac{\pi}{6}a^3$, a being the diameter.

Ex. 4. Let the solid be a parabole spindle which is generated by the revolution of APB, an arc of a parabola, about ACB, an ordinate to its axis. From P any point in

Fig. 30.



the revolving curve, draw PQ perpendicular to the ordinate AB, and PR perpendicular to the axes of the parabola. Make DC $= p$, AC $= q$, CQ $=$ PR $= x$, PQ $=$ CR $= y$, the solid (between the sections DEF, PGp) $= s$. By the nature of the curve, $PR^2 : AC^2 = DR : DC$; that is, $x^2 : q^2 = p - y : p$; hence $p\,x^2 = pq^2 - q^2 y$, and $y^2 = \frac{p^2}{q^4}(q^4 - 2q^2x^2 + x^4)$, and

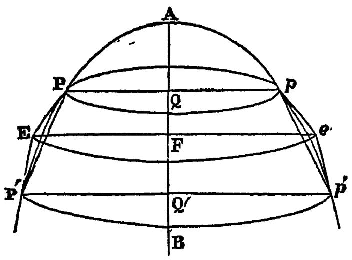
$$s = \frac{p^2\pi}{q^4}\int(q^4dx - 2q^2x^2dx + x^4dx)$$
$$= \frac{p^2\pi}{q^4}(q^4x - \tfrac{2}{3}q^2x^3 + \tfrac{1}{5}x^5) + \mathrm{C}.$$

If the integral begin when $x = 0$, then $\mathrm{C} = 0$. If we make $x = q$, we get $\frac{8}{15}p^2.q\pi$ for half the content of the solid generated by the curve ADB.

Surfaces of Solids.

164. Let AB be the axis of any plane curve APP′, and PQ, P′Q′ ordinates to the axis; draw PE, P′E tangents to the curve at P and P′, meeting in E; draw EF perpendicular to AB, and draw the chord PP′.

Fig. 31.



Suppose now the curve to revolve about its axis AB; the arc APP′ will generate a curve surface, to be found; the portion PP′ of the arc will generate an increment of that surface, which, by an axiom in geometry, will be less than the sum of the conical surfaces generated by the tangents PE, P′E, but greater than the conical surface generated by the chord PP′. Put AQ $= x$, AQ′ $= x'$, PQ $= y$, P′Q′ $= y'$, EF $= y''$, arc AP $= z$, arc AP′ $= z'$, surface generated by arc AP $= v$, surface generated by arc AP′ $= v'$.

By the elements of geometry, the surfaces generated by the tangents PE P′E will be

$$\pi(\mathrm{PQ} + \mathrm{EF})\,\mathrm{PE} = \pi(y + y'')\,\mathrm{PE},$$
$$\pi(\mathrm{P'Q'} + \mathrm{EF})\,\mathrm{P'E} = \pi(y' + y'')\,\mathrm{P'E},$$

and the surface generated by the chord PP′ will be

$$\pi(\mathrm{PQ} + \mathrm{P'Q'})\,\mathrm{PP'} = \pi(y + y')\,\mathrm{PP'}.$$

Therefore $v' - v < \pi\{(y + y'')\,\mathrm{PE} + (y' + y'')\,\mathrm{P'E}\}$,

$$v' - v > \pi(y + y')\text{ chord PP}',$$

and $$\frac{v' - v}{z' - z} < \pi\frac{(y + y'')\,\mathrm{PE} + (y' + y'')\,\mathrm{P'E}}{\text{arc P}'\mathrm{P}},$$

$$\frac{v' - v}{z' - z} > \pi(y + y')\frac{\text{chord P}'\mathrm{P}}{\text{arc P}'\mathrm{P}}.$$

Now, the point P being supposed to approach to P′, these quantities, one of which is greater than $\frac{v' - v}{z' - z}$, and the other less, become ultimately equal; for the lines y, y'', y' become equal, and $(y + y'')\,\mathrm{PE} + (y + y'')\,\mathrm{PE}$ becomes $(y' + y)(\mathrm{PE} + \mathrm{P'E})$, and the fractions $\frac{\mathrm{PE} + \mathrm{P'E}}{\text{arc P}'\mathrm{P}}$, $\frac{\text{chord PP}'}{\text{arc PP}'}$ are ultimately each $= 1$; therefore,

$$\text{limit}\,\frac{v' - v}{z' - z} = 2\pi y,\ \text{and}\ \frac{dv}{dz} = 2\pi y;$$

hence, $dv = 2\pi y dz = 2\pi y\sqrt{dx^2 + dy^2}$.

Now $2\pi y$ expresses the circumference of the section Pp; hence it appears that *the differential of the surface of revolution is equal to the differential of the arc of the generating curve multiplied by a section of the surface made by a plane perpendicular to the axis.*

165. Ex. 1. Let the solid be a sphere, of which the radius is a. Then, making AQ$=x$, PQ$=y$, the arc AP$=z$, the surface of the segment cut off by the plane P$p = v$; the equation of the curve being $y = \sqrt{2ax - x^2}$, we have

$$dy = \frac{adx - xdx}{\sqrt{2ax - x^2}},\ dz = \sqrt{dx^2 + dy^2} = \frac{adx}{\sqrt{2ax - x^2}} = \frac{adx}{y},$$

$dv = 2\pi y dz = 2a\pi dx$, and the surface $v = 2a\pi x$; here no constant is wanted, because we suppose that when $x = 0$, then $v = 0$.

Since $2a\pi$ is the circumference of a circle whose diameter is a, it follows that *the curve surface of a segment of a sphere is equal to a rectangle contained by a straight line equal to the circumference of the sphere and the height of the segment;* and hence it follows, that *the whole surface of the sphere is four times the area of one of its great circles.* These conclusions were found by Archimedes.

Ex. 2. To find the surface of a paraboloid. Put AQ $= x$, PQ $= y$, arc AP $= z$, curve surface generated by AP $= v$, the parameter $= 2a$. We found (article 160)

$dz = \frac{dy}{a}\sqrt{a^2 + y^2}$, hence,

$$dv = 2\pi y dz = \frac{2\pi}{a}\,ydy\sqrt{a^2 + y^2},$$

and, integrating, $v = \frac{2\pi}{a}\int ydy\sqrt{a^2+y^2} = \frac{2\pi}{3a}(a^2+y^2)^{\frac{3}{2}} + \mathrm{C}$.

When $v = 0$, then $y = 0$; therefore, at the vertex we have

$$0 = \frac{2\pi a^3}{3a} + \mathrm{C}\ \text{and}\ \mathrm{C} = -\frac{2\pi a^3}{3a};$$

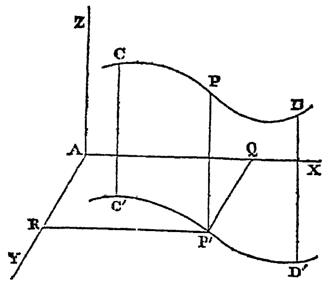
therefore, substituting for C, we have

$$v = \frac{2\pi}{3a}\{(a^2+y^2)^{\frac{3}{2}} - a^3\} = \frac{2}{3}\pi\{\sqrt{a(2x+a)}^3 - a^2\}.$$

Rectification of Curves of Double Curvature.

166. Let CPD be a line of double curvature referred to three co-ordinate planes YAX, ZAX, ZAY. From every point in the curve let perpendiculars PP′, &c. be drawn to one of the planes, YAX; these will all be in the surface of a cylinder that meets the plane in a curve C′P′D, which will be the projection of the proposed curve. Again, from P′ draw P′Q, P′R perpendicular to AX, AY. Let AQ $=$ P′R $= x$, AR $=$ P′Q $= y$, P′P $= z$, the arc CP $= v$, its projection C′P′ $= v'$: Then $dv' = \sqrt{dx^2 + dy^2}$, (art 72). Suppose now the cylindric surface to be extended into a plane surface; the curve CPD will then be changed into a common plane curve, and its projection C′P′D′ into a straight line of the same length as before. We may now consider

Fig. 32.



v' and z as co-ordinates of the curve v, and then $dv = \sqrt{dv'^2 + dz^2}$; therefore, by substituting for dv'^2 its value $dx^2 + dy^2$, we find

$$dv = \sqrt{dx^2 + dy^2 + dz^2}.$$

This is a general formula for the rectification of any line of double curvature. The nature of the line will be expressed by two equations $f(x, y) = 0$, $F(x, z) = 0$. From these we find $dy = Pdx$, $dz = Qdx$, expressions in which P and Q are functions of x only. Thus we have $dv = dx\sqrt{1 + P^2 + Q^2} = dxR$, R being a function of the single variable x. The integral $v = \int Rdx$ may now be found by the ordinary rules.

Integration of Differential Equations of two Variables.

167. Every differential equation of the first order which contains only the single powers of dx and dy, has the form $Mdx + Ndy = 0$, and it expresses the relation which subsists between the variable x, the function y, and its differential co-efficient $\frac{dy}{dx}$. The object of inquiry is to discover, if possible, the primitive equation $f(x, y) = 0$, which by differentiation may produce the proposed differential equation.

168. The method which first presented itself to analysts was to endeavour to separate the variables, so as to give it the form $Xdx + Ydy = 0$, X being a function of x alone, and Y a function of y. When this can be done, the differentials Xdx, Ydy are separately integrable, and we have $\int Xdx + \int Ydy = C$ an arbitrary constant.

Let the equation be $mydx + nxdy = 0$; by dividing its terms by xy, it is changed to $\frac{mdx}{x} + \frac{ndy}{y} = 0$. The variables are now separated, and we have $\int \frac{mdx}{x} + \int \frac{ndy}{y} = m\,l.\,x + n\,l.\,y = C$, or $l.\,(x^m) + l.\,(y^n) = C$, or $l.\,(x^m y^n) = C$. We may suppose $C = l.\,c$, and then $x^m y^n = c$ is the primitive equation.

The variables may be separated when the differential equation has the form $Xdy + Ydx = 0$, X being a function of x, and Y a function of y; for then $\frac{dx}{X} + \frac{dy}{Y} = 0$.

169. The variables may always be separated in *homogeneous equations*, the distinguishing property of which is, that the sum of the exponents of x and y is the same in each of its terms. For example, $ax^m y^n dx + bx^{m-1} y^{n+1} dy$ is a homogeneous equation; because the sum of the exponents of x and y is $m + n$ in each term. Let $Mdx + Ndy = 0$ be a homogeneous equation. Make $y = xz$, then M will take the form Zx^m, and N the form $Z_1 x^m$, Z and Z_1 being functions of z only; and since $dy = zdx + xdz$, the equation will be, after dividing by x^m, $Zdx + Z_1(xdz + zdx) = 0$, a result which may be put under the form

$$\frac{dx}{x} + \frac{Z_1 dz}{Z + zZ_1} = 0;$$

from which we get

$$\int \frac{dx}{x} + \int \frac{Z_1 dz}{Z + zZ_1} = C.$$

170. Ex. 1. Let us apply this transformation to the equation $xdx + ydy = nydx$ or $(x - ny)\,dx + ydy = 0$, which, making $y = xz$, and therefore $dy = xdz + zdx$, becomes $x(1 - nz)\,dx + x^2zdz + xz^2dx = 0$, or $(1 - nz + z^2)\,dx + xzdz = 0$, and $\int \frac{dx}{x} + \int \frac{zdz}{1 - nz + z^2} = C$, or $l.\,x + \int \frac{zdz}{1 - nz + z^2} = C$. This integral may be simplified by observing that

$$\frac{zdz}{1 - nz + z^2} = \frac{1}{2}\,\frac{2zdz - ndz}{1 - nz + z^2} + \frac{1}{2}\,\frac{ndz}{1 - nz + z^2},$$

for it then becomes

$$l.\,x + \tfrac{1}{2}\,l.\,(1 - nz + z^2) + \tfrac{1}{2}\int \frac{ndz}{1 - nz + z^2} = C.$$

The integral which yet remains to be found will depend on logarithms, if $\frac{1}{2}n > 1$; on arcs of circles, if $\frac{1}{2}n < 1$; and will be algebraical if $\frac{1}{2}n = 1$. In each case it may be had by the methods given for integrating rational fractions.

Ex. 2. Let it be proposed to integrate the equation

$$xdy - ydx = dx\sqrt{x^2 + x^2}.$$

By making $y = xz$, bringing all the terms to one side of the equation, and dividing by x, we shall have $dx\sqrt{1 + z^2} - xdz = 0$, and hence

$$\frac{dx}{x} - \frac{dz}{\sqrt{1 + z^2}} = 0;$$

and by the separate integration of each term,

$$l.\,x - l.\,(z + \sqrt{1 + z^2}) = l.\,C, \text{ or } \frac{x}{z + \sqrt{1 + z^2}} = C.$$

and replacing z by its value x, there will result

$$\frac{x^2}{y + \sqrt{x^2 + y^2}} = C, \text{ or } -y + \sqrt{x^2 + y^2} = C;$$

and hence again, by transposing y, and squaring, $x^2 = C^2 + 2Cy$, which is the primitive equation.

The equation

$$(a + mx + ny)\,dx + (b + px + qy)\,dy = 0,$$

which is not homogeneous in its present form, may be transformed so as to become homogeneous. Assume $x = t + \alpha$, $y = u + \beta$, then $dx = dt$, $dy = du$, and the proposed equation becomes

$$(a + m\alpha + n\beta + mt + nu)dt + (b + p\alpha + q\beta + pt + qu)du = 0.$$

To make the constant terms disappear, we assume $a + m\alpha + n\beta = 0$, $b + p\alpha + q\beta = 0$, equations which determine α and β, and then there remains the different equation

$$(mt + nu)\,dt + (pt + qu)\,du = 0,$$

which is homogeneous in respect of the new variables t and u. This transformation gives no result when $mq - np = 0$, a case in which α and β become infinite; but then $q = \frac{np}{m}$; and consequently $m\,(px + qy) = p\,(mx + ny)$. The proposed equation being changed to

$$adx + bdy + (mx + ny)\left(dx + \frac{p}{m}dy\right) = 0,$$

Inverse Method.

we now make $mx + ny = z$, so that $dy = \frac{dz - mdx}{n}$; by substitution and proper reduction our equation now becomes

$$dx + \frac{(bm + pz)\,dz}{amn - bm^2 + m\,(n - p)\,z} = 0.$$

The integral of this equation will contain logarithms, except in the case where $n = p$, when it will be

$$x + \frac{2bmz + pz^2}{2m\,(an - bm)} = \text{C}.$$

171. The separation of the variables is easily effected in the equation $dy + \text{P}ydx = \text{Q}dx$, where P and Q denote any functions whatever of x. Substituting Xz and $z d$X + Xdz instead of y and dy, it becomes

$$z d\text{X} + \text{X}dz + \text{PX}zdx = \text{Q}dx.$$

Here X denotes an indeterminate function of x, to which we may give such a form as shall conduce to the separation of the variables. For this purpose we make $\text{X}dz + \text{PX}zdx = 0$, which requires that $zd\text{X} = \text{Q}dx$. If we divide the first equation by X, it becomes $dz + \text{P}zdx = 0$, from which we deduce $\frac{dz}{z} + \text{P}dx = 0$, and $\text{l}.\,z + \int \text{P}x = 0$; and passing from logarithms to numbers, $z = e^{-\int \text{P}dx}$ (here e is the base of Napier's logarithms), we neglect the arbitrary constant in the mean time, as it will be added at the end of the operation. Afterwards, deducing the value of dX from the second equation, and substituting it in the first, we shall have

$$d\text{X} = e^{\int \text{P}dx}\,\text{Q}dx,\ \text{X} = \int e^{\int \text{P}dx}\,\text{Q}dx + \text{C},$$

and consequently,

$$y = e^{-\int \text{P}dx}\{\int e^{\int \text{P}x}\,\text{Q}dx + \text{C}\}$$

Ex. Let the equation be $dy + ydx = ax^3\,dx$: then $\text{P} = 1, \text{Q} = ax^3, \int \text{P}dx = x, e^{\int \text{P}dx} = e^x, e^{-\int \text{P}dx} = e^{-x}$; $\int e^{\int \text{P}dx}\,\text{Q}dx = \int ae^x\,x^3dx = ae^x\,(x^3 - 3x^2 + 6x - 6)$; therefore $y = e^{-x}\,\{ae^x(x^3 - 3x^2 + 6x - 6) + \text{C}\}$
$= \text{C}e^{-x} + a\,(x^3 - 3x^2 + 6x - 6)$.

172. The early writers on the integral calculus classed differential equations by the number of their terms. In equations which had but two terms, and whose form is consequently $\beta u^g z^h dz = au^e z^f du$, the variables are separated immediately, since we thence deduce $\beta z^{h-f} dz = au^{e-g} du$. This however is not the case with equations of three terms, which are expressed by the formula

$$\gamma u^i z^k\,dz + \beta u^g z^h\,du = au^e z^f du.$$

This may be simplified by dividing the terms by $\gamma u^i z^f$, it then becomes

$$z^{k-f}dz + \frac{\beta}{\gamma}u^{g-i}z^{h-f}du = \frac{\alpha}{\gamma}\,u^{e-i}\,du.$$

Suppose now $z^{k-f}dz = \frac{dy}{k-f+1}$, $u^{g-i}du = \frac{dx}{g-i+1}$; then we have $z^{k-f+1} = y$, $u^{g-i+1} = x$, and

$$dy + \frac{(k-f+1)\beta}{(g-i+1)\gamma}y^{\frac{k-f}{k-f+1}}dx = \frac{(k-f+1)\alpha}{(g-i+1)\beta}x^{\frac{e-g}{g-i+1}}dx.$$

To abridge, let us put

$$b = \frac{(k-f+1)\,\beta}{(g-i+1)\,\gamma},\quad a = \frac{(k-f+1)\,\alpha}{(g-i+1)\,\gamma},$$
$$n = \frac{h-f}{k-f+1},\quad m = \frac{e-g}{g-i+1};$$

and the equation will become

$$dy + by^n dx = ax^m dx.$$

When $n = 1$, the equation belongs to the class treated of in last article. When $n = 2$, the equation is

$$dy + by^2 dx = ax^m dx,$$

which was first considered by an Italian geometer, *Riccati*, whose name it bears. When $m = 0$, the variables are separable, and we have

$$dx = \frac{dy}{a - by^2}.$$

Proceeding from this case, analysts have succeeded in separating the variables when m is any number of the form $\frac{-4i}{2i \pm 1}$, i being supposed an integer number. Riccati's equation was first considered by James Bernoulli, who gave an approximate solution of it. (Jac. Bernoulli *Opera*, p. 1053.) The general problem, however, remains yet unresolved.

173. When a differential equation is the immediate result of the differentiation of a known function, then that function, put equal to C a constant, will be the integral required. The differential equation $xdy + ydx = 0$ is of this class; it is the differential of the product xy, therefore the primitive equation is $xy = \text{C}$. A differential equation may, however, not be the immediate result of the differentiation of a function of x and y; it may be formed by the elimination of some constant quantity contained in the function and also in its differential (art. 54); or it may be the result after the differential of the primitive has been divided by some factor common to all its terms. Thus, if the primitive be $y = cx$, or $y - cx = 0$, the differential equation is $dy - cdx = 0$. If however we eliminate c by the usual algebraic process, we find $xdy - ydx = 0$, an expression which is not the immediate result of any differentiation. The same result will be obtained if the primitive $x = cy$ be put under the form $\frac{x}{y} = c$; for then, by differentiating, $\frac{ydx - xdy}{y^2} = 0$, and, rejecting the factor $\frac{1}{y^2}$, $ydx - xdy = 0$. This expression is not an exact differential; however, it becomes so by restoring the factor $\frac{1}{y^2}$, and then it is the differential of $\frac{x}{y}$.

174. In general let $u = f(x, y)$ be the primitive equation, the differential being $du = \text{M}dx + \text{N}dy$, where M denotes $\frac{du}{dx}$, that is, the differential co-efficient found on the supposition that x is variable and y constant, and N denotes $\frac{du}{dy}$, the co-efficient taken on the reverse hypothesis of y being variable and x constant; now we have found that $\frac{d^2u}{dxdy} = \frac{d^2u}{dydx}$ (art. 89); therefore, if $\text{M}dx + \text{N}dy$ be the differential of $u = f(x, y)$, then

$$\frac{d\text{M}}{dy} = \frac{d\text{N}}{dx}\text{......................}(1)$$

Hence, *If* Mdx + Ndy *is an exact differential, the condition expressed by formula* (1) *will always be satisfied. And, conversely, if* M *and* N *are such functions of* x *and* y *that* $\frac{\text{dM}}{\text{dy}} = \frac{\text{dN}}{\text{dx}}$, *then* Mdx + Ndy *shall be an exact differential, and in every case its integral may be found.* This is called the *Condition of Integrability*.

To prove the second part of the proposition, let us sup-

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pose that the integral of Mdx is taken on the supposition that in the function M, x is variable and y constant; and let the integral be $P+Y$, where Y is any function of y, which comes in the place of the indeterminate constant that enters into every integral, and P is a known function of x and y, which results from $\int Mdx$ relatively to x only, so that $M=\frac{dP}{dx}$.

The complete differential of $P+Y$ is (art. 91) $\frac{dP}{dx}dx+\frac{dP}{dy}dy+dY$, or $Mdx+\frac{dP}{dy}dy+dY$. By comparing this with the differential $Mdx+Ndy$, it appears that it such a value be given to Y that $Ndy=\frac{dP}{dy}dy+dY$ or that

$$dY=\left(N-\frac{dP}{dy}\right)dy \text{..............(2)}$$

then the integral of $Mdx+Ndy$ will be $P+Y$. Now, by differentiating $M=\frac{dP}{dx}$ in respect of y, we have $\frac{dM}{dy}=\frac{d^2P}{dydx}$, but by hypothesis $\frac{dM}{dy}=\frac{dN}{dx}$, and $\frac{d^2P}{dydx}=\frac{d^2P}{dxdy}$ (art. 89), therefore $\frac{dN}{dx}=\frac{d^2P}{dxdy}$, and $\frac{dN}{dx}-\frac{d^2P}{dxdy}=0$, that is, $d\left(N-\frac{dP}{dy}\right)=0$, the differential being taken supposing x only to be variable; therefore $N-\frac{dP}{dy}$ is constant in respect of x, and is a function of y only; hence the possibility of finding $Y=\int\left(N-\frac{dP}{dy}\right)dy$ is proved, and we have the integral of $Mdx+Ndy$ expressed by $P+\int\left(N-\frac{dP}{dy}\right)dy$, and here $P=\int Mdx$, the integral being taken on the supposition that y is constant.

We may begin with finding the integral of Ndy, supposing x to be constant, proceeding in all respects as has been explained. In general we ought to begin with the term which brings out the integral with least calculation.

Ex. 1. It is proposed to find whether the differential $\frac{ydx-xdy}{x^2+y^2}$ satisfies the condition of integrability, and, if it does, to integrate it.

We put the differential under the form

$$du=\frac{y}{x^2+y^2}dx-\frac{x}{x^2+y^2}dy,$$

therefore $M=\frac{y}{x^2+y^2}$, $N=-\frac{x}{x^2+y^2}$,

$$\frac{dM}{dy}=\frac{x^2-y^2}{(x^2+y^2)^2},\quad \frac{dN}{dx}=\frac{x^2-y^2}{(x^2+y^2)^2}.$$

The condition of integrability is in this case satisfied, and therefore $\frac{ydx-xdy}{x^2+y^2}$ is an exact differential.

To determine the integral, we have

$$P=\int Mdx=\int\frac{ydx}{x^2+y^2}=\int\frac{\frac{dx}{y}}{1+\frac{x^2}{y^2}}=\tan^{-1}\frac{x}{y},$$

whence $u=\tan^{-1}\frac{x}{y}+Y$.

Differentiating, and considering the whole as variable,

$$du=\frac{ydx-xdy}{x^2+y^2}+dY.$$

This, compared with the proposed differential, shows that $dY=0$, and $Y=C$ a constant.

Ex. 2. To find the integral of the differential

$$du=(2y^2x+3y^3)\,dx+(2x^2y+9xy^2+8y^3)\,dy.$$

In this example, $M=2y^2x+3y^3$, $N=2x^2y+9xy^2+8y^3$,

$$\frac{dM}{dy}=4yx+9y^2=\frac{dN}{dx};$$

the proposed function is therefore a complete differential.

Integrating in respect of x, we find

$$\int Mdx=y^2x^2+3y^3x+Y,$$

and $u=y^2x^2+3y^3x+Y$.

Differentiating this expression in respect of y,

$$\frac{du}{dy}=2x^2y+9xy^2+\frac{dY}{dy},$$

but we had $\frac{du}{dy}=2x^2y+9xy^2+8y^3$;

therefore, $\frac{dY}{dy}=8y^3$, and $Y=\int 8y^3dy=2y^4+C$,

and consequently the integral is

$$u=y^2x^2+3y^3x+2y^4+C.$$

175. If in the equation $Mdx+Ndy=0$, the condition of integrability, viz. $\frac{dM}{dy}=\frac{dN}{dx}$, is not satisfied, we may next inquire whether some factor, a function of x and y, can be found by which the expression $Mdx+Ndy$ can be rendered a complete differential.

Let the equation be put under the form $\frac{dy}{dx}+K=0$, where $K=\frac{M}{N}$. This equation is the result of the elimination of a constant quantity c between a primitive equation, which may be represented by $f(x,y,c)=0$ and its immediate differential. Or else c may be eliminated directly by bringing the primitive equation to the form $F(x,y)=c$, which will lead to the same result (art 53). Put u for $F(x,y)$, also Pdx for the differential of u taken relatively to x, and Qdy for its differential relatively to y, so that $du=Pdx+Qdy$, and $\frac{du}{dx}=P+Q\frac{dy}{dx}=0$, therefore $P+Q\frac{dy}{dx}=0$. Since this equation does not contain C, it ought to be identical with the equation $\frac{dy}{dx}+K=0$;

therefore $\frac{dy}{dx}+K=\frac{dy}{dx}+\frac{P}{Q}=\frac{Pdx+Qdy}{Qdx}$, that is, $\frac{dy}{dx}+K=\frac{du}{Qdx}$, and hence

$$Q(dy+Kdx)=du.$$

Now the second side of the equation is a complete integral; hence it appears that *there is always a factor* Q, *by which, if the differential equation* dy + Kdx = 0 *be multiplied, the result will be a complete integral.*

Let both sides of the equation be multiplied by U, any function of U, and we have

$$UQ(dy+Kdx)=Udu.$$

Now Udu is still a complete differential, and as the factor UQ may have an infinite variety of forms, it follows that *there are an infinite number of factors, such that if a differential equation be multiplied by any one of them, it will be a complete differential.*

Since it appears that when the equation $Mdx + Ndy = 0$ does not satisfy the condition of integrability, it is because differentiation and subsequent elimination of the arbitrary constant have caused a factor to disappear, which, if it were known and restored, would render the expression a complete differential, the discovery of that factor is a most important problem in the calculus. Its solution, however, transcends the present powers of analysis, although it can be resolved in particular cases. When the functions M and N are homogeneous, the factor can be found; but that case can always be integrated as has been explained. When the variables can be separated, a multiplier can be found, but then it is not wanted. It can also be found when the equation has the form $dy + Pydx = Qdx$; but this also can be integrated by other means.

Euler, who has entered deeply into this subject, has reversed the problem; and, in his *Calculus Integralis*, supposing the integrating factor given, has investigated the nature of the functions which must enter into a differential equation of a given form, in order that it may be integrable. These investigations, however, frequently lead to differential equations, which cannot be integrated by any known method; and the cases in which they are successful are of no great importance or extent.

176. Let M be any function of x and y, and let $u = \int Mdx$, the integral being taken on the supposition that x is variable and y constant: it is sometimes required that the differential co-efficient $\frac{du}{dy}$ be found; or, in other words, that the differential of $\int Mdx$ relatively to y be found without having actually integrated the expression relatively to x. Because $u = \int Mdx$, therefore $\frac{du}{dx} = M$, and $\frac{d^2u}{dxdy} = \frac{dM}{dy}$; but $\frac{d^2u}{dxdy} = \frac{d^2u}{dydx}$ (art. 89), therefore $\frac{d^2u}{dydx} = \frac{dM}{dy}$, and $\frac{d^2u}{dy} = \frac{dM}{dy}dx$, and integrating relatively to x, $\frac{du}{dy} = \int \frac{dM}{dy}dx$.

Ex. Let $u = \int \frac{ydx}{\sqrt{y^2 - x^2}}$, here $M = \frac{y}{\sqrt{y^2 - x^2}}$, and $\frac{dM}{dy} = \frac{-x^2}{(y^2 - x^2)^{\frac{3}{2}}}$, and $\frac{du}{dy} = \int \frac{-x^2dx}{(y^2 - x^2)^{\frac{3}{2}}}$.

The theorem investigated in this article was found by Leibnitz, and was reckoned an important discovery in the calculus. (See Bossut, *Traité du Calcul Diff.* &c. vol. ii, p. 58.)

177. The elimination of a constant contained in a primitive equation may introduce the second or higher powers of the differentials into the resulting differential equation (art. 53): in such cases we must find the values of $\frac{dy}{dx}$ by the resolution of an equation.

For example, if $dy^2 - a^2dx^2 = 0$, or $\frac{dy^2}{dx^2} = a^2$, we have $\frac{dy}{dx} = \pm a$ and $dy + adx = 0$, also $dy - adx = 0$; therefore $y + ax + c = 0$ and $y - ax + c' = 0$ are two primitive equations, from each of which the differential equation may be derived; also from their product $(y + ax + c)(y - ax + c') = 0$.

178. When the equation contains only one of the variables, x for example, we deduce from it $\frac{dy}{dx} = X$, and $y = \int Xdx$; but if the equation be more easily resolvable with respect to x than with respect to the co-efficient $\frac{dy}{dx}$, which we will represent by p, and if we have also $x = P$, a function of p, and thence $dx = dP$; then, since $dy = pdx$, therefore $dy = pdP$, and $y = pP - \int Pdp$. The relation between x and y is now to be found by eliminating p by means of the equations

$$x = P, \ y = Pp - \int Pdp.$$

Let us take as an example $xdx + ady = b\sqrt{dx^2 + dy^2}$, or $x + ap = b\sqrt{1 + p^2}$, by writing p in the place of $\frac{dy}{dx}$. This last equation gives immediately $x = -ap + b\sqrt{1 + p^2}$, and consequently

$$y = bp\sqrt{1 + p^2} - \tfrac{1}{2}ap^2 - b\int dp\sqrt{1 + p^2}.$$

179. When the primitive equation cannot be deduced from the differential equation by any of the known artifices of analysis, then, as a last resource, recourse must be had to approximation by infinite series.

Ex. Let the differential equation be $dy + ydx = mx^ndx$, and suppose it to be known that when $x = a$, then $y = b$: we now make $x = a + t$, $y = b + u$, the equation by this transformation becomes $du + (b + u)dt = m(a + t)^ndt$. We now assume that

$$u = At^\alpha + Bt^{\alpha+1} + Ct^{\alpha+2} + \&c.$$

and hence, putting instead of u and du their values, and bringing the terms to one side, we have

$$\left.\begin{array}{l} \alpha At^{\alpha-1} + (\alpha + 1)Bt^\alpha + (\alpha + 2)Ct^{\alpha+1} + \&c. \\ + b \quad + \quad At^\alpha \quad + \quad Bt^{\alpha+1} + \&c. \\ - ma^n - m\frac{n}{1}a^{n-1}t - m\frac{n(n-1)}{1.2}a^{n-2}t^2 - \&c. \end{array}\right\} = 0.$$

In this equation we must suppose $\alpha - 1 = 0$, and we shall then find

$$A = ma^{n-1} - b, \ B = \frac{mna^{n-1} - ma^n + b}{1.2},$$
$$C = \frac{mn(n-1)a^{n-2} - mna^{n-1} + ma^n - b}{1.2.3}, \ \&c.$$

These values being substituted in the series, we have u expressed by t and known quantities; we may then put $x - a$ for t, and $y - b$ for u, and the result will express the relation between x and y.

In the series assumed for the value of u, the exponents of t form an arithmetical progression, of which the common difference is 1. In many cases, however, the common difference will be a fraction, as in this example, $(dx + dy)y = dx$. Here we assume

$$y = Ax^a + Bx^b + Cx^c + \&c.$$

By proceeding as before, there is obtained

$$\left.\begin{array}{llll} A^2ax^{2a-1} & + ABax^{a+b-1} + ACax^{a+c-1} + \&c. & & \\ & + ABbx^{a+b-1} + B^2bx^{2b-1} + \&c. & & \\ & \qquad + AC\,cx^{a+c-1} + \&c. & & \\ -1 & + Ax^a \qquad + Bx^b \qquad + \&c. & & \end{array}\right\} = 0.$$

Hence $2a - 1 = 0$, $a + b - 1 = a$, $a + c - 1 = b$, &c.; therefore $a = \frac{1}{2}$, $b = 1$, $c = \frac{3}{2}$, &c.

Again, $A^2a = 1$, $AB(a + b) + A = 0$, &c.

Hence $A = \sqrt{2}$, $B = -\frac{2}{3}$, $C = \frac{1}{18}\sqrt{2}$, &c.

and $y = x^{\frac{1}{2}}\sqrt{2} - \frac{2}{3}x^{\frac{2}{2}} + \frac{1}{18}x^{\frac{3}{2}}\sqrt{2} - \&c.$

On the integration of differential equations by series, consult Euler, *Instit. Cal. Integ.* vol. i. sect. 2; Lacroix, *du Calcul Diff.* part ii. chap. 6.

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Differential Equations of the Second and Higher Orders.

180. The difficulty of the integrations becomes so much the greater the higher the order of the differential co-efficients which they involve, and we only succeed in effecting it in a very small number of very limited equations.

Let the expression

$$f(x, y, c, c') = 0 \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

represent any primitive equation composed of the variables x, y, and two constant quantities c, c', besides any other constants. By differentiation (as explained art. 48–54), there is formed its differential equation of the first order, which will contain $\frac{dy}{dx}$. Let this differential co-efficient be represented by p, and let $q = \frac{dp}{dx} = \frac{d^2y}{dx}$. The differential of the first order will contain x, y, p, c, c', and may be represented by

$$f'(x, y, p, c, c') = 0 \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

By differentiating this equation we obtain another which contains also $\frac{d^2y}{dx^2} = q$, and may be expressed by

$$f''(x, y, p, q, c, c') = 0 \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Since these three equations must hold true at once, we may eliminate the constants c, c', and the result will be a single equation,

$$F(x, y, p, q) = 0 \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

in which c, c' are not found. This will be the differential equation of the second order, deducible from the primitive (1), and which is independent of the constants c, c'.

We may arrive at the very same equation (4) in two other ways. We may give the primitive (1) these forms:

$$\varphi(x, y, c) = c', \quad \psi(x, y, c') = c,$$

from which, by differentiation, two results will be obtained, one entirely free from c', and the other from c: these again may have the forms

$$\varphi'(x, y, p) = c, \quad \psi'(x, y, p) = c'.$$

By taking now the differentials of these equations, we shall obtain the very same equation from each, which will be identical with equation (4).

For example, let the primitive equation be

$$x^2 - 2ax + 2by = 0,$$

in which a and b represent the constants c, c'; by differentiation, we find

$$x - a + b\frac{dy}{dx} = 0, \quad 1 + b\frac{d^2y}{dx^2} = 0.$$

After eliminating a and b by the three equations, we have this differential equation,

$$2y - 2x\frac{dy}{dx} + x^2\frac{d^2y}{dx^2} = 0.$$

We may otherwise put the primitive equation under these forms:

$$\frac{x^2 + 2by}{x} = 2a, \quad \frac{x^2 - 2ax}{y} = -2b.$$

Taking now the differentials, and arranging the results so that the constants may stand alone, and putting p instead of $\frac{dy}{dx}$, we have

$$\frac{x^2}{y - xp} = 2b, \quad \frac{2xy - x^2p}{y - xp} = 2a.$$

By differentiating either of these, the constants disappear, and in each case the result is the same, viz.

$$2y - 2x\frac{dy}{dx} + x^2\frac{d^2y}{dx^2} = 0.$$

181. Since two of the constants in a primitive equation may not be found in the differential equation of the second order derived from it, so, reversely, in returning from a differential equation of the second order to its absolute primitive, *the latter cannot be complete unless it contain two arbitrary constants, which are not in the former;* and as the same differential equation of the second order may be obtained from two distinct differential equations of the first order, it follows that *every differential equation of the second order has two distinct differential equations of the first order, each having its own arbitrary constant; and these again have one and the same absolute primitive equation.* The properties of differential equations of the third and higher orders are perfectly analogous to these.

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182. The most simple differential equation of the second order is $\frac{d^2y}{dx^2} = X$, a function of x; then $\frac{dy}{dx} = \int X dx$. Let P be the variable part of the integral $\int X dx$, and c the constant, so that $\frac{dy}{dx} = P + c$; hence again $dy = Pdx + cdx$, and by a second integration, $y = \int Pdx + cx + c'$. Since $\int Pdx = Px - \int xdP = x\int Xdx - \int xXdx$, therefore,

$$y = x\int Xdx - \int xXdx + cx + c'.$$

The primitive of the differential equation $d^3y - Xdx^3 = 0$ may be found in the same way. We first put it under the form $\frac{d^3y}{dx^2} = Xdx$; then we have by a first integration $\frac{d^2y}{dx^2} = \int Xdx = P + c$; and hence $\frac{d^2y}{dx} = Pdx + cdx$; by a second integration, $\frac{dy}{dx} = \int Pdx + cx + c' = P' + cx + c$; here $P' = \int Pdx$. We have now $dy = P'dx + cxdx + c'dx$; and lastly, $y = \int P'dx + \frac{1}{2}cx^2 + c'x + c''$. The primitive thus containing three arbitrary constants: a like differential equation of the fourth order would contain four, and so on.

183. When a differential equation of the second order involves $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$, and constants; if we put $\frac{dy}{dx} = p$, then, regarding dx as constant, $\frac{d^2y}{dx^2} = \frac{dp}{dx}$; the equation will now involve p, dp, dx and constants; and it will be of the first order, in respect of p and x. We may thence find $dx = Pdp$, P being here put for some function of p; and since $dy = pdx = Ppdp$, we have

$$x = \int Pdp, \quad y = \int Ppdp.$$

These integrals being found, and a constant added to each, by eliminating p, we find an equation expressing the relation between x and y.

Ex. To integrate the equation $\frac{(dx^2 + dy^2)^{\frac{3}{2}}}{dxd^2y} = a$. By putting pdx for dy, and $dpdx$ for d^2y, the equation is changed to $\frac{(1+p^2)^{\frac{3}{2}}dx}{dp} = a$, from which we deduce

$$dx = \frac{adp}{(1 + p^2)^{\frac{3}{2}}}, \quad dy = pdx = \frac{apdp}{(1 + p^2)^{\frac{3}{2}}}.$$

The integration gives

$$x = c + \frac{ap}{\sqrt{1 + p^2}}, \quad y = c' - \frac{a}{\sqrt{1 + p^2}}.$$

Hence $(c - x)^2 + (y - c')^2 = a^2$.

The proposed differential equation is nothing more than the general expression of the radius of curvature (art. 78) made equal to a constant quantity a. We have resolved the geometrical problem, to find a curve whose radius of

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curvature is a constant, and found it to be a circle, as was obvious.

184. We may remark, that the equation $x = C + \int \frac{dp}{P}$, and $dy = C' + \int \frac{pdp}{P}$, severally satisfy the differential equation $\frac{dp}{dx} = P$; and that, by supposing their second members integrated, they will be only of the first order. This agrees with what was observed, art. 181, viz. that there are two equations of the first order which satisfy a differential equation of the second order.

185. Let us now consider differentials of the form $\frac{d^2y}{dx^2} = Y$, Y representing any function of y. If we make $dy = pdx$, we thence deduce $dx = \frac{dy}{p}$, which gives $\frac{d^2y}{dx^2} = \frac{dp}{dx} = \frac{pdp}{dy}$. Substituting this in the proposed equation, there results from it $pdp = Ydy$; by integrating, we find $p^2 = 2\int Ydy$, C, and hence

$$p = \frac{dy}{dx} = \sqrt{C + 2\int Ydy}, \text{ and } x = \int \frac{dy}{\sqrt{C + 2\int Ydy}} + C'.$$

It is proper to observe that the above integration may be effected by multiplying the proposed equation by dy, for thence we find $\frac{dy}{dx} \cdot \frac{d^2y}{dx} = Ydy$; and since $\frac{d^2y}{dx} = d\frac{dy}{dx}$, we have $\frac{1}{2}\frac{dy^2}{dx^2} = \int Ydy + C$, or $\frac{dy}{dx} = \sqrt{2\,C + 2\int Ydy}$.

Ex. Let the equation be $d^2y\sqrt{ay} = dx^2$; we shall have

$$\frac{d^2y}{dx^2} = \frac{1}{\sqrt{ay}}, \quad \frac{dy}{dx} \cdot \frac{d^2y}{dx} = \frac{dy}{\sqrt{ay}},$$

and, by integrating, $\frac{1}{2}\frac{dy^2}{dx^2} = \frac{2}{a}\sqrt{ay} + C$; changing C into $\frac{2c}{\sqrt{a}}$, we shall deduce from thence

$$\frac{dy^2}{dx^2} = \frac{4}{\sqrt{a}}(\sqrt{y} + c), \quad \frac{2dx}{\sqrt[4]{a}} = \frac{dy}{\sqrt{c + \sqrt{y}}}.$$

Now, making $c + \sqrt{y} = z$, there will result

$$\frac{dx}{\sqrt[4]{a}} = \frac{(z-c)}{\sqrt{z}}\,dz = (z^{\frac{1}{2}} - cz^{-\frac{1}{2}})dz;$$

and finally,

$$\frac{x}{\sqrt[4]{a}} = \tfrac{2}{3}z^{\frac{3}{2}} - 2cz^{\frac{1}{2}} + c' = \tfrac{2}{3}(\sqrt{y} - 2c)\sqrt{c + \sqrt{y}} + c'.$$

186. We have seen in the differential calculus, art. 93, that beyond the first order the form of the differential equations would be changed, according as x or y, or even a function of these quantities, was assumed as the *independent variable*; which comes to the same thing as assuming that dx, or dy, or a given function of these variables, was constant. It is therefore necessary, in integrating equations which exceed the first degree, to know upon which of these hypotheses it has been calculated. The preceding examples all correspond to the case of y being a function of x, and consequently of dx being constant; but it will be easy to discover, among relations deduced relatively to other hypotheses, to which of them they may be referred.

It is immediately evident that, if we represent by Q any function whatever of $\frac{dx}{dy}$, every equation of the form $\frac{d^2x}{dy^2} = Q$, and in which dy is constant, may be treated in the same way as that in art. 183, by making $\frac{dx}{dy} = q$, and $\frac{d^2x}{dy^2} = \frac{dq}{dy}$. It may also be reduced immediately to the form $\frac{d^2y}{dx^2} = P$, by passing by the formula of art. 93, to the hypothesis of dx being constant, which will be effected by the substitution of $\frac{-dxd^2y}{dy^3}$ in place of $\frac{d^2x}{dy}$.

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If the proposed equation had been taken on the supposition of $\sqrt{dx^2 + dy^2}$ being constant, and if it involved only dx, dy, d^2y, or dy, dx, dx^2, it might still be treated in the same manner as that of art. 183, after transforming it into one in which dx was constant.

187. When the equation contains $\frac{d^2y}{dx^2}$, $\frac{dy}{dx}$ and the variable x, it may, as before, be transformed into a differential equation of the first order, by substituting pdx for dy, and $dpdx$ for d^2y; then, if the primitive of that differential equation, and thence the value of p in terms of x, can be found, we may have the value of y from the formula $y = \int pdx$; or else, if we have the value of x in terms of p, then, because $\int pdx = px - \int xdp$, we shall have $y = px - \int xdp$.

Ex. Let the equation be

$$-\frac{(dx^2 + d^2y)^{\frac{3}{2}}}{dxd^2y} = X \text{ or } -\frac{(1+p^2)^{\frac{3}{2}}dx}{dp} = X,$$

where x denotes a given function of x; then

$$\frac{dx}{X} = \frac{-dp}{(1+p^2)^{\frac{3}{2}}} \text{ and } \int \frac{dx}{X} + C = \frac{-p}{\sqrt{1+p^2}}.$$

Let V represent $\int \frac{dx}{X} + C$, then $p = \frac{V}{\sqrt{1 - V^2}}$, and $y = \int pdx + C' = \int \frac{Vdx}{\sqrt{1 - V^2}} + C'$; y is now expressed by means of x only. This is the analytical solution of the geometrical problem to find the nature of a curve whose radius of curvature shall be a given function of x, the absciss.

If we suppose $X = \frac{a^2}{2x}$, then $\frac{-p}{\sqrt{1+p^2}} = \int \frac{2xdx}{a^2} = \frac{x^2}{a} + C$,

$$p^2 = \frac{dy^2}{dx^2} = \frac{x^2 + c}{a^4 - (x^2 + c^2)^2} \text{ and } y = \int \frac{(x^2 + c)dx}{\sqrt{\{a^4 - (x^2 + c)^2\}}};$$

here c is put generally for an indeterminate constant. This is the equation of the elastic curve.

188. If the proposed differential equation is composed of $\frac{d^2y}{dx^2}$, $\frac{dy}{dx}$, and y, we may, as before, put $p = \frac{dy}{dx}$, from which we get $\frac{d^2y}{dx^2} = \frac{dp}{dx} = \frac{pdp}{dy}$; the equation will now involve dp, dy, p and y only. When the primitive equation can be found, and thence the value of p in terms of y, we may find x by the formula $x = \int \frac{dy}{p}$; but when y is expressed by p, we may then employ the formula $x = \frac{y}{p} + \int \frac{ydp}{p^2}$.

189. Differentials of the second order, which have this form,

$$\frac{d^2y}{dx^2} + P\frac{dy}{dx} + Qy = R,$$

in which P, Q, R are any functions of x, are called *linear*, also equations of the *first degree*, because y is only of one dimension. It will easily be understood that the difficulty of finding the primitive equation will be greater than in the like equation of the first order; and, indeed, except in particular cases, there is no known method of reducing the integration to the finding of the differential of a single variable; that is, to the quadrature of a curve. If $R=0$, in which case the equation is

$$\frac{d^2y}{dx^2}+P\frac{dy}{dx}+Qy=0,$$

it may be reduced to a differential equation of the first degree, by a very simple transformation. Let e, as usual, denote the base of Napier's logarithms; assume $y=e^{\int udx}$, then, regarding dx as constant, we have

$$dy=udxe^{\int udx},\ d^2y=e^{\int udx}\ (dudx+u^2dx^2):$$

the value of dy and d^2y being substituted in the equation, and the common factors rejected, it becomes

$$du+(u^2+Pu+Q)\,dx=0.$$

When P and Q are constants, which may be represented by A and B, the equation becomes

$$du+(u^2+Au+B)\,dx=0;$$

in which the variables are separated, if we give it the form

$$\frac{du}{u^2+Au+B}+dx=0.$$

As it is merely necessary to satisfy this equation, we may make $u=m$, m being any constant; then $du=0$, and $m^2+Am+B=0$. This last equation gives, in general, two values of m; if we represent them by a and b, we shall have two values of $\int udx$; viz. $ax+c$ and $bx+c'$, and hence we have two values of y, viz.

$$y=e^{ax+c},\quad y=^{bx+c'};$$

or, putting C for e^c, and C′ for $e^{c'}$,

$$y=Ce^{ax},\quad y=C'e^{bx}.$$

These, however, are only *particular* values of the function y, because each contains only a single arbitrary constant; but by adding them, we get

$$y=Ce^{ax}+C'e^{bx}$$

as the complete primitive equation.

To prove this, by differentiating, we get

$$\frac{dy}{dx}=aCe^{ax}+bC'e^{bx},\ \frac{d^2y}{dx^2}=a^2Ce^{ax}+b^2C'e^{bx}.$$

From these and the above primitive equation, we have, after eliminating C and C′,

$$\frac{d^2y}{dx^2}+(a+b)\frac{dy}{dx}-aby=0.$$

This will agree with the proposed equation, if we give a and b such values that $a+b=P$, $ab=-Q$.

If a and b come out impossible quantities, the exponents of a and b in the value of y will have the form

$$a=\alpha+\beta\sqrt{-1},\ b=\alpha-\beta\sqrt{-1};$$

we have then

$$y=Ce^{\alpha x+\beta x\sqrt{-1}}+C'e^{\alpha x-\beta x\sqrt{-1}}$$
$$=e^{\alpha x}\left(Ce^{\beta x\sqrt{-1}}+C'e^{-\beta x\sqrt{-1}}\right);$$

This result is rendered real by eliminating the imaginary quantities, by means of sines and cosines; thus we have (ALGEBRA, art. 269),

$$e^{\beta x\sqrt{-1}}=\cos\beta x+\sqrt{-1}\sin\beta x,$$
$$e^{-\beta x\sqrt{-1}}=\cos\beta x-\sqrt{-1}\sin\beta x,$$
$$y=e^{\alpha x}\{(C+C')\cos\beta x+(C-C')\sqrt{-1}\sin\beta x\};$$

and making $C+C'=c$, $(c-c')\sqrt{-1}=c'$,

$$y=e^{\alpha x}\,(c\cos\beta x+c'\sin\beta x);$$

or, making $c=p\sin q$, $c'=p\cos q$,

$$y=pe^{\alpha x}\sin(\beta x+q).$$

When the roots a and b are equal, the value of y being reduced to

$$Ce^{ax}+C'e^{ax}=(C+C')e^{ax},$$

it becomes incomplete. In this case we may proceed, as in art. 58, by supposing that a and b differ by a very small quantity. Let us suppose that $b=a+k$, there thence results

$$y=Ce^{ax}+C'e^{ax+kx}=e^{ax}(C+C'e^{kx}):$$

developing e^{kx} according to the powers of k, we have

$$y=e^{ax}(C+C'+C'kx+C'\frac{k^2x^2}{2}+\&c.)$$

or, putting $C+C'=c$ and $c'k=c'$

$$y=e^{ax}(c+c'x+c'k\frac{x^2}{2}+\&c.)$$

This last expression, which satisfies the proposed equation for all values of k, agrees with it likewise if $k=0$, or $b=a$; and, in that case, it becomes

$$y=e^{ax}(c+c'x).$$

190. When P and Q are variable quantities, functions of x, then if v and v' are two values of y which each satisfy the equation

$$\frac{d^2y}{dx^2}+P\frac{dy}{dx}+Qdy=0,$$

we may take

$$y=cv+c'v$$

for the complete primitive equation. For then $dy=cdv+cdv'$, $d^2y=cd^2v+cd^2v$, and the differential equation becomes

$$c\left(\frac{d^2v}{dx^2}+P\frac{dv}{dx}+Qv\right)+c,\left(\frac{d^2v}{dx^2}+\frac{dv'}{dx}+Qv'\right)=0.$$

Now, by hypothesis,

$$\frac{d^2v}{dx^2}+P\frac{dv}{dx}+Qv=0;\ \frac{d^2v'}{dx^2}+P\frac{dv'}{dx}+Qdv'=0.$$

Therefore the equation is identical, and so the value of y is truly determined.

As an example of the integration of a differential equation of the second degree, see the article ARCH (art. 57).

191. We shall now give an example of the integration of a differential equation of the first degree and the second order.

Let the equation be

$$d^2y+ax^nydx^2=0.$$

If we suppose

$$y=Ax^\alpha+Bx^{\alpha+\delta}+Cx^{\alpha+2\delta}+\&c.$$

and that the series of exponents is an increasing one, or that δ is positive, we may, when x is supposed very small, conceive y to reduce itself to its first term, since the others are too small to be compared with this first. On this supposition, we may confine ourselves to assuming

$$y=Ax^\alpha;\text{ then }d^2y=\alpha(\alpha-1)Ax^{\alpha-2}dx^2,$$

and the proposed equation will become

$$\alpha(\alpha-1)Ax^{\alpha-2}+aAx^{\alpha+n}=0.$$

It is not possible to determine α so as to make the two exponents $\alpha-2$ and $\alpha+n$ equal, except in the particular case of $n=-2$; but the exponent of x being greater in the second term than the first, we may neglect one of these terms in comparison with the other; and the equation may then be verified in two ways (by approxi-

Inverse Method.

mation), viz. by making $\alpha = 0$, and $\alpha = 1$, since upon either hypothesis the term $\alpha(\alpha - 1)\, Ax^{\alpha - 2}$ (the greatest in the equation) vanishes: A, therefore, remains indeterminate, and we have two series, one beginning with A, and the other with Ax.

If we take successively

$$y = A + Bx^{\delta} + cx^{2\delta} + \&c.$$
$$y = Ax^{1+\delta} + Bx^{1+2\delta} + cx^{1+2\delta} + \&c.$$

and substitute for y these values, and for d^2y its corresponding values, we shall then find, by properly arranging the terms, that δ must be $= 2$; and, in either case, determining the values of the co-efficients A, B, C, &c. we arrive at these two series,

$$A - \frac{aAx^{n+2}}{(n+1)(n+2)} + \frac{a^2Ax^{2n+4}}{(n+1)(n+2)(2n+3)(2n+4)} - \frac{a^3Ax^{3n+6}}{(n+1)(n+2)(2n+3)(2n+4)(3n+5)(3n+6)} + \&c.$$

$$Ax - \frac{aAx^{n+3}}{(n+2)(n+3)} + \frac{a^2Ax^{2n+5}}{(n+2)(n+3)(2n+4)(2n+5)} - \frac{a^3A^{3n+7}}{(n+2)(n+3)(2n+4)(2n+5)(3n+6)(3n+7)} + \&c.$$

These developments are only particular cases, since they contain each but one arbitrary constant A; but, on account of the particular form of the proposed example (189), we shall obtain a general expression for y, by writing in the latter of them A_1 for A, and taking their sum.

Having now given as full a view of the principles of the fluxional calculus as we conceive to be compatible with the nature of our work, we shall conclude with a few more examples of its application to geometry.

Problem 1.

To find the length of the enlarged meridian in *Mercator's*, or rather *Wright's* projection of the sphere.

In this projection, the meridians and parallels of latitude are straight lines, which intersect each other at right angles; and the projection of any small arc of a meridian (as one minute), reckoned from any parallel, is to the projection of a like arc of longitude in that parallel, as radius to the cosine of the latitude of the parallel, that is, in the same ratio as the arcs themselves in the sphere. Supposing the radius of the sphere to be unity, let v be any arc of latitude reckoned from the equator, z its projection on the chart, or the *enlarged meridian.* Let v' and z' be any small increments of v and z; then, by the principles of the projection, $\frac{z'}{v'} = \frac{rad}{\cos v}$; therefore, putting the ratio of the differentials for the limit of the ratio of the increments, $\frac{dz}{dv} = \frac{1}{\cos v}$, and $dz = \frac{dv}{\cos v}$. Therefore, taking the integral (art. 155), $z = \text{l.}\left\{\tan\left(45° + \tfrac{1}{2}v\right)\right\}$. Here no correction is wanted, because when $v = 0$, then $z = \text{l.}(\tan 45°) = \text{l.}(1) = 0$, as it should be.

Henry Bond, in the year 1650, discovered, by chance, that the enlarged meridian might be expressed by the logarithmic tangents of half the complements of the latitudes, a rule easily found from the preceding solution; but the difficulty of proving this was then considered so great, that Mercator offered to wager a sum of money against any person that should undertake to prove it either true or false. James Gregory, however, proved it in his *Exercitationes Geometricæ*, published in 1668; also Barrow, in his Geometrical Lectures: their demonstrations, however, were intricate. Afterwards Dr Wallis and Dr Halley gave demonstrations which were sufficiently simple and elegant.

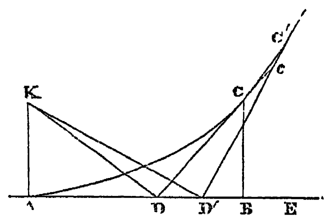
Problem 2.

If any number of straight lines are drawn according to some determinate law, it is required to find the nature of a curve to which these are tangents.

For example, let AE be a straight line given by position, and K a given point without it; let any number of lines KD, KD′, &c. be drawn to meet AE in D, D′, &c.; and let perpendiculars DC, D′C′, &c. be drawn to these lines; it is required to find the nature of the curve ACC′, to which these perpendiculars are tangents.

Without attending to the particular case, we shall resolve the general problem, and suppose AE to be the axis of

Fig. 33.



the curve, A being the origin of the co-ordinates, and CD any position of the tangent, which meets the axis in D. From the point of contact C draw the perpendicular CB; and, considering C as a point in the curve, put $AB = x$, $BC = y$; but again considering C as any point whatever in the tangent, put $AB = x'$, $BC = y'$. Then, whatever be the conditions that determine the position of the tangent, the relation of x' and y', the co-ordinates of any point in it, may be expressed by the equation $y' = Px' + Q$, where P and Q are put to denote generally certain functions of constant quantities, and some quantity p, which has the same value for any given position of the tangent, but which changes its value if the tangent changes its position. For example, p may express the angle which the tangent makes with the axis, or it may represent the subtangent BD, &c.

Let us now suppose that the variable quantity p changes its value, and becomes $p + h$, and that C′ D′ is the new position of the tangent corresponding to $p + h$; then, considering P and Q as functions of p, by Taylor's theorem (art. 31),

$$\text{P becomes } P + \frac{dP}{dp}h + \frac{d^2P}{dp^2}\frac{h^2}{2} + \&c.$$
$$\text{Q becomes } Q + \frac{dQ}{dp}h + \frac{d^2Q}{dp^2}\frac{h^2}{2} + \&c.$$

The relation of x' to y' in the new position of the tangent will now be expressed by the equation

$$y' = Px' + Q + \left(\frac{dP}{dp}x' + \frac{dQ}{dp}\right)h + Kh^2 + \&c.$$

Where Kh^2 + &c. is put for all the remaining terms of the series.

Now, as this equation holds true of every point in the

tangent C′D′, and the equation $y' = \mathrm{P}x' + \mathrm{Q}$ holds true of every point in the tangent CD, it follows that at c, the intersection of the two tangents, both equations must be true at the same time; therefore at c we have

$$\left(\frac{d\mathrm{P}}{dp}x' + \frac{d\mathrm{Q}}{dp}\right)h + \mathrm{K}h^2 + \&\text{c.} = 0;$$

and, dividing by h, $\dfrac{d\mathrm{P}}{dp}x' + \dfrac{d\mathrm{Q}}{dp} + \mathrm{K}h + \&\text{c.} = 0.$

Conceive now the two tangents to approach to coincidence; when C′ comes to C, then c will also fall at C; and h, and all the terms into which it enters, vanish; also x' and y' become x and y: and, to determine the nature of the curve, we have these two equations:

$$y = \mathrm{P}x + \mathrm{Q} \text{.......................................} (1)$$

$$0 = \frac{d\mathrm{P}}{dp}x + \frac{d\mathrm{Q}}{dp} \text{.................................} (2)$$

By eliminating p from these, the resulting equation will express the nature of the curve.

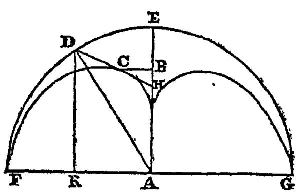
Ex. 1. Let us now recur to the particular case of AE, a straight line given by position, K a given point, and KDC a right angle: Draw KA perpendicular to AE; put $\mathrm{AB} = x$, $\mathrm{BC} = y$, $\mathrm{KA} = a$, and let AD be the variable quantity p. The triangles KAD, DBC are manifestly similar; therefore KA : AD = DB : BC, that is, $a : p = x - p : y$; hence $ay = px - p^2$, and $y = \dfrac{p}{a}x - \dfrac{p^2}{a}$. Compare this with equation (1), and it will appear that $\mathrm{P} = \dfrac{p}{a}$, $\mathrm{Q} = -\dfrac{p^2}{a}$; therefore $\dfrac{d\mathrm{P}}{dp} = \dfrac{1}{a}$; $\dfrac{d\mathrm{Q}}{dp} = -\dfrac{2p}{a}$; hence the nature of the curve is expressed by the two equations

$$y = \frac{p}{a}x - \frac{p^2}{a};\ \ 0 = \frac{1}{a}x - \frac{2p}{a}.$$

The second of these equations gives $p = \frac{1}{2}x$; and hence the first becomes $y = \dfrac{x^2}{2a} - \dfrac{x^2}{4a}$; therefore $4\,ay = x^2$ is the equation of the curve, which is evidently a parabola, of which AK is the axis, K the focus, and A the vertex.

Ex. 2. Suppose a ray of light RD, coming from the sun, to fall upon FEG, the concave surface of a sphere, at D, and to be thence reflected in the direction DH; it is proposed to find the nature of the curve to which this, and all rays reflected in the same manner, are tangents.

Fig. 34.



Draw AD the radius of the sphere, and AE parallel to the incident ray RD; let C be the point in which the reflected ray touches the curve; let DC meet AE in H, and draw CB perpendicular to AE. Put $\mathrm{AD} = a$, $\mathrm{AB} = x$, $\mathrm{BC} = y$, and let p be the variable angle DAE.

By the principles of optics, AD bisects the angle RDH, which is equal to DHE, that is, to the sum of the angles DAH, ADH; therefore the angles ADH, DAH are equal, and angle $\mathrm{DHE} = 2p$. Now, by trigonometry,

$$\mathrm{AH} = \frac{\sin \mathrm{ADH}}{\sin \mathrm{AHD}} \times \mathrm{AD} = \frac{\sin p}{\sin 2p}a,$$

$$\mathrm{BH} = \frac{\cos \mathrm{CHB}}{\sin \mathrm{CHB}} \times \mathrm{CB} = \frac{\cos 2p}{\sin 2p}y;$$

Hence $x = (\mathrm{AH} + \mathrm{BH}) = \dfrac{\sin p}{\sin 2p}a + \dfrac{\cos 2p}{\sin 2p}y,$

and $y = \dfrac{\sin 2p}{\cos 2p}x - \dfrac{\sin p}{\cos 2p}a \text{........................} (\alpha)$

By comparing this with the general formula (1), it appears that

$$\mathrm{P} = \frac{\sin 2p}{\cos 2p},\ \mathrm{Q} = -\frac{\sin p}{\cos 2p}a;\ \text{hence,}$$

$$\frac{d\mathrm{P}}{dp} = \frac{2}{\cos^2 2p},\ \frac{d\mathrm{Q}}{dp} = -\frac{\cos p}{\cos 2p}a - \frac{2\sin 2p \sin p}{\cos^2 2p}a.$$

Hence, by formula (2),

$$\frac{2x}{\cos^2 2p} = \left\{\frac{\cos p}{\cos 2p} + \frac{2\sin 2p \sin p}{\cos^2 2p}\right\}a \text{............} (\beta)$$

From equations (α) and (β) we readily find

$$x = (\tfrac{1}{2}\cos 2p \cos p + \sin 2p \sin p)\,a,$$

$$y = (\tfrac{1}{2}\sin 2p \cos p - \cos 2p \sin p)\,a;$$

and hence, by observing that $\sin 2p = 2 \sin p \cos p$, and that $\cos 2p = 2\cos^2 p - 1 = 1 - 2\sin^2 p$ (*Arithmetic of Sines*, ALGEBRA), we have also

$$= \tfrac{1}{2}\cos p\,(1 + 2\sin^2 p)\,a;\ y = (\sin^3 p)a.$$

From these equations it is easy to eliminate the trigonometrical quantities $\cos p$ and $\sin p$, and the result will be the equation of the curve, which is an epicycloid. The curve in question is the *catacaustic* curve to a circle.

It is easy to see that the general problem, of which we have now given two examples, is very comprehensive. We may evidently find, by the formulæ (1) and (2), *catacaustic* and *diacaustic* curves in all cases whatever. These, and an infinite number of other geometrical problems, are contained in the following more general problem.

Problem 3.

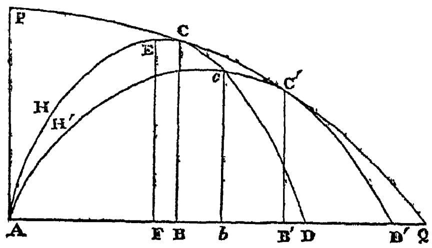
Determine the nature of a curve which touches an infinite number of lines of a given kind, described upon a plane according to some determinate law. For example, suppose the lines to be parabolas described by a projectile thrown from an engine with a given velocity, at every possible elevation in a vertical plane.

Let HCD be any one of the lines of a given kind (a parabola, for example), and suppose it referred to an axis AB, by the rectangular co-ordinates $\mathrm{AB} = x'$ and $\mathrm{BC} = y'$. Let p denote some quantity belonging to the line or curve HCD, which has always the same value in the same curve, but which has different values in different curves. Thus, if the curve be a circle, p may be its radius; or if the curve be a parabola, p may be its parameter, &c. This quantity p may also by analogy be called the *parameter* of the curve HCD. Let us suppose the nature of this curve to be expressed by the equation

$$f(x', y', p) = 0 \text{.........................} (1)$$

that is, let some function of x', y', and p, be supposed $= 0$. If p now be supposed to change its value, and become $p + h$, then the curve HCD will change its figure, and have some other position H′C′D′. Let $\mathrm{AB}' = x''$, and B′C′

Fig. 35.



Inverse Method.

$= y''$, be any co-ordinates of this other curve, and as, by hypothesis, the two curves are expressed by equations of the same form, we must have

$$f(x'', y'', p+h) = 0;$$

and this expression, by Taylor's theorem, is equivalent to
(2)

$$f(x'', y'', p) + \frac{d\{f(x'', y'', p)\}}{dp}h + \text{K}h^2 + \&c.,$$

the differential being taken upon the hypothesis that p alone is variable, and $\text{K}h^2$ + &c. being put for all terms of the series following the second, each of which is multiplied by a power of h.

Let the two curves intersect each other in c, and let $\text{A}b = x$, and $cb = y$, be the common co-ordinates; then, as equation (1) holds true of every point in the curve HCD, and equation (2) holds true of every point in H′C′D′, both must hold true at once, if we substitute in them x and y, the co-ordinates belonging to their common point c; that is, we must have

$$f(x, y, p) = 0,$$

$$f(x, y, p) + \frac{d\{f(x, y, p)\}}{dp}h + \text{K}h^2 + \&c. = 0;$$

and hence we must also have

$$\frac{d\{f(x, y, p)\}}{dp} + \text{K}h + \&c. = 0.$$

Let C and C′ be now supposed the points in which the curves HcD, H′cD′ touch the curve PCC′Q, whose nature is required; then, if we suppose h to decrease continually, and at last to vanish, the points C′ and c will approach to C, and at last will coincide with it, so that x and y, which are co-ordinates of c, the intersection of the two curves HcD, H′cD′, will then become the co-ordinates of the curve PCQ. As all the terms which contain h will then vanish, we have evidently this rule.

Let the equation of the given curves be

$$f(x, y, p) = 0\ldots\ldots\ldots\ldots\ldots(\alpha)$$

x and y being the co-ordinates, and p a variable parameter. From this equation, by taking the differential, supposing p to be variable, and all the other quantities constant, we deduce this other equation,

$$\frac{d\{f(x, y, p)\}}{dp} = 0\ldots\ldots\ldots(\beta)$$

By these eliminate p, and the result will be an equation, which expresses the nature of the curve that touches all the given curves.

Ex. Let ACD, AC′D′, &c. be parabolas described by a projectile thrown from a given point A, with a given velocity, in a given vertical plane. It is proposed to find the curve PCQ which touches them all. Let EF be the axis of any one of the curves, AD an ordinate to the axis, $\text{AP} = a$ the height due to the velocity of projection, $\text{AB} = x$, $\text{BC} = y$, the co-ordinates of C, any point in the curve. Put the parameter of the axis $= p$, and considering AD as a function of p, which is to be regarded as variable, put $\text{AD} = q$.

By the theory of projectiles, $\text{EF} = a - \frac{1}{4}p$, and by the nature of the parabola, $\text{AF}^2 = p \times \text{EF}$, and $\text{AB} \times \text{BD} = p \times \text{BC}$; hence we have these two equations,

$$qx - x^2 = py, \ (1) \qquad q^2 = 4ap - p^2, \ (2)$$

From the first of these,

$$f(x, y, p) = x^2 + py - qx = 0;$$

and, taking the differentials, considering x and y as constant, and q as a function of the variable quantity p,

$$\frac{d\{f(x, y, p)\}}{dp} = y - \frac{dq}{dp}x = 0,$$

therefore $\frac{y}{x} = \frac{dq}{dp}$; but from equation (2), taking the differentials, $qdq = 2adp - pdp$, and hence $\frac{dq}{dp} = \frac{2a - p}{q}$, and by the first equation $\frac{y}{x} = \frac{q - x}{p}$, therefore $\frac{q - x}{p} = \frac{2a - p}{q}$, and hence $q^2 - qx = 2ap - p^2$; and substituting for q^2 its value given by equation (2), we get $qx = 2ap$; hence, and by equation (1),

$$p = \frac{x^2}{2a - y}, \qquad q = \frac{2ax}{2a - y}.$$

These values of p and q being substituted in the second equation, and the common denominator rejected, it becomes

$$4a^2x^2 = (8a^2 - 4ay - x^2)x^2.$$

Hence $4\,ay = 4\,a^2 - x^2$, and this is the equation of the curve PCQ, which is evidently a parabola having its focus at A, the common intersection of all the parabolas, its axis perpendicular to the horizon, and its parameter $= 4\,a$.

The geometrical theory comprehended in the second and third problems has a corresponding analytical theory relating to the integrals of certain differential equations. This is the theory of *singular* primitive equations, which are not included in the *complete* primitive equation. Thus, the differential equation

$$dy \sqrt{(x^2 + y^2 - b)} - ydx - xdx = 0,$$

has for its complete primitive equation

$$x^2 - 2ay - a^2 - b = 0,$$

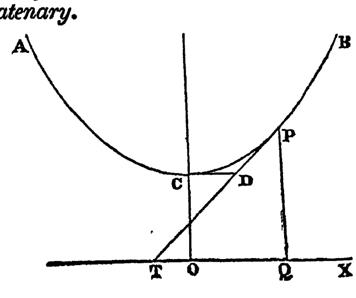
where a is the arbitrary constant quantity; but, besides this, it has a *singular* primitive equation,

$$x^2 + y^2 - b = 0,$$

which does not admit of an arbitrary constant, although it equally satisfies the differential equation, as is easily proved by differentiating. The bounds within which it was proper to confine this treatise have not allowed us to enter into this branch of the subject, which, although interesting, is yet not elementary.

Investigation of the Properties of the Catenary.

Suppose a chain or thread of uniform thickness, and perfectly flexible, but inextensible, to be fastened by its extremities at two points A, B in a vertical plane; by the action of gravity it will take the form of a curve ACPB, called the *catenary*.



The curve will evidently be all in one plane, and a horizontal line CD, in that plane, at C its lowest point, will manifestly touch the curve, which is retained at rest by a mutual balancing of the forces produced by the weight of the particles of the chain.

If we suppose its lowest point to be fixed at C, it is easy to understand that the part BC will not on that account change in the least its figure, because the tension of the chain at C, when it was free, is now replaced by the reaction of the force exerted in the horizontal direction CD.

Inverse Method.

The forces exerted on the points B, C will evidently be the same in quantity and in direction, whether the chain be considered as flexible, or rigid like a solid wire; hence it may be regarded as kept at rest by three forces, viz. its gravity acting vertically, and the re-actions of the tensions at B and C; the former exerted in the direction of a tangent to the curve at B, and the latter in the direction CD, the tangent at the lowest point C.

In like manner any portion PC between P and its lowest point may be considered as kept at rest by the joint action of the gravity of the mass PC, the tension of the chain at C, which is constant, and the tension at P, which is variable; and by the nature of an equilibrium (MECHANICS), these forces will be to each other as the sides of any triangle which are parallel to their directions. Draw a horizontal line OX in the plane of the curve as an axis, meeting the vertical through C in O, which may be taken as an origin of co-ordinates; draw PQ perpendicular to OX, and PT touching the curve and meeting the axis in T. From what has been explained, the tension of the curve at C will be to the weight of the matter in PC as TQ to PQ, that is, as radius to the tangent of the angle which PT makes with any horizontal line.

Put $OQ = x$, $PQ = y$, arc $CP = z$, angle $PTQ = \varphi$; and let a be the tension of the curve at the vertex C: we have then $a : z = 1 : \tan \varphi$; hence

$$\tan \varphi = \frac{z}{a} \quad \text{.........................(1)}$$

This is the distinguishing property of the curve, from which we are to deduce its other properties.

From equation (1), by differentiation,

$$\frac{d\varphi}{\cos^2 \varphi} = \frac{dz}{a}.$$

Now in all curves,

$$dz = \frac{dx}{\cos \varphi} = \frac{dy}{\sin \varphi};$$

hence we obtain

$$dx = a \,.\, \frac{d\varphi}{\cos \varphi}, \quad dy = a \,.\, \frac{d\varphi \sin \varphi}{\cos \varphi}.$$

From these, by integration,

$$x = a \,\text{l.} \tan (45^\circ + \tfrac{1}{2}\varphi) + \text{const. (art. 155)}$$

$$y = \frac{a}{\cos \varphi} + \text{const.}$$

If we assume that OC measures the tension at C, which is a constant quantity, then because when $\varphi = 0$, $x = 0$, and $y = a$, we have the relation of the quantities x, y, φ, expressed by these equations,

$$\left. \begin{aligned} x &= a \,\text{l.} \tan (45^\circ + \tfrac{1}{2}\varphi), \\ y &= \frac{a}{\cos \varphi} = a \sec \varphi. \end{aligned} \right\} \quad \text{.....................(2)}$$

The constant line a is called the *parameter* of the curve, also its *modulus*. From the first of these equations, putting ψ for $45^\circ + \tfrac{1}{2}\varphi$, we have

$$\tan \psi = e^{\frac{x}{a}}, \; \cot \psi = e^{\frac{-x}{a}},$$

$$\tan \psi + \cot \psi = e^{\frac{x}{a}} + e^{\frac{-x}{a}}.$$

Now,
$$\tan \psi + \cot \psi = \frac{\sin \psi}{\cos \psi} + \frac{\cos \psi}{\sin \psi},$$

$$= \frac{2}{\sin 2\psi} = \frac{2}{\cos \varphi} = \frac{2y}{a};$$

therefore
$$y = \frac{a}{2}\left\{ e^{\frac{x}{a}} + e^{\frac{-x}{a}} \right\} \quad \text{........................(3)}$$

This exponential equation expresses the relation between x and y by means of e, the base of Napier's logarithms. From this last equation, observing that $y = a \sec \varphi$, we get

$$\sec^2 \varphi = \tfrac{1}{4}\left\{ e^{\frac{2x}{a}} + e^{\frac{-2x}{a}} + 2 \right\},$$

$$\sec^2 \varphi - 1 = \tfrac{1}{4}\left\{ e^{\frac{2x}{a}} + e^{\frac{-2x}{a}} - 2 \right\},$$

$$\tan \varphi = \sqrt{\sec^2 \varphi - 1} = \tfrac{1}{2}\left\{ e^{\frac{x}{a}} - e^{\frac{-x}{a}} \right\}.$$

But it was found that $z = a \tan \varphi$,

therefore
$$z = \frac{a}{2}\left\{ e^{\frac{x}{a}} - e^{\frac{-x}{a}} \right\} \quad \text{..................(4)}$$

From formulæ (3) and (4) we have

$$y + z = ae^{\frac{x}{a}}, \quad y - z = ae^{\frac{-x}{a}} \quad \text{............(5)}$$

therefore $y^2 - z^2 = a^2$ ....(6)

hence again,

$$y = \sqrt{a^2 + z^2}, \; z = \sqrt{y^2 - a^2} \quad \text{....................(7)}$$

and since from formula (5)

$$\frac{x}{a} = \text{l.} \frac{y + z}{a} = \text{l.} \frac{a}{y - z} \quad \text{..........................(8)}$$

therefore also,
$$\frac{x}{a} \left\{ \begin{aligned} &= \text{l.} \frac{y + \sqrt{y^2 - a^2}}{a} \\ &= \text{l.} \frac{z + \sqrt{z^2 + a^2}}{a} \end{aligned} \right\} \quad \text{..........(9)}$$

Let s denote the area bounded by the arc PC and the straight lines CO, OQ, PQ; then, since $dx = \frac{a d\varphi}{\cos \varphi}$, and $y = \frac{a}{\cos \varphi}$, therefore

$$ds = y dx = \frac{a^2 d\varphi}{\cos^2 \varphi} = a dz.$$

and $s = az$ ....(10)

Thus it appears that the arc CP is always proportional to the conterminous area CPQO. It is evident that the catenary, if inverted, would form an equilibrated arch. From this property it appears that if a wall, whose height above the crown of the arch is equal to the line CO, be horizontal at the top, the structure thus formed will constitute an equilibrated arch with a straight roadway. (See on this subject our article ARCH.) (W. W.)

FLY. See *Diptera*, index to ENTOMOLOGY.

FLY, in *Mechanics*, the name of an appendage to many machines, either as a regulator of their motions or as an accumulator of power. It is usually in the form of a metal disc, or a wheel with a heavy rim, sometimes in that of a cross or bar loaded at the extremities, and is attached to the revolving shaft of the machine in order to distribute the force of the power equally in all parts of its revolution. When used as an accumulator of power for the purpose of producing a very great instantaneous effect, as in the coining press, it is frequently seen in the form of heavy knobs at the opposite extremities of a straight bar. The fly is especially useful in all cases where the power or the resistance acts with an irregular or intermitting force in the different parts of a revolution.

FLY-CATCHER. See index to ORNITHOLOGY.

FLYING, the progressive motion of a bird or other winged animal through the air.

Artificial FLYING. Attempts have been made by various persons in all ages to imitate the motions of birds in the air by means of mechanical contrivances, but hitherto with very little success—the balloon being the only known machine that can sustain the body of a man in the air for any considerable length of time. Friar Bacon tells us that he knew how to make a machine by which a man might convey himself through the air like a bird; and he adds, that a person had tried it with success. The secret consisted in a couple of large thin hollow copper globes, exhausted of air; which being much lighter than common air, would sustain a chair on which a person might sit and be buoyed along. Father Francisco Lana, in his *Prodromo*, proposes the same thing. He computes that a round vessel of plate-brass, fourteen feet in diameter, weighing three ounces the square foot, will only weigh 1848 ounces, whereas a quantity of air of the same bulk will weigh 2155$\frac{2}{3}$ ounces, so that the globe will not only be sustained in the air, but will carry with it a weight of 307$\frac{2}{3}$ ounces; and by increasing the bulk of the globe without increasing the thickness of the metal, he conceives that a vessel might be made to carry a much greater weight. But the fallacy is obvious. A globe of the dimensions he describes, as shown by Dr Hook, would not sustain the pressure of the air, but be crushed inwards. Besides, in whatever ratio the bulk of the globe is increased, in the same ratio must the thickness of the metal, and consequently the weight, be increased; so that there would be no advantage in such augmentation.

The philosophers of Charles II.'s time were much busied about this art. The celebrated Bishop Wilkins was so confident of success in the attempt, that he says he does not question but in future ages it will be as usual to hear a man call for his wings when he is going a journey as it is now to call for his boots. Among such contrivances may be noticed another, consisting of huge wings, the cavities of which are to be filled with hydrogen gas, and which the flying man is to move with his arms. It is almost needless to observe that this machine is quite incapable of effecting the object in view, as must be every other constructed upon the same principle.

The flying apparatus constructed by Sir George Cayley can scarcely be considered as a successful experiment, since the wings of that ingenious mechanician acted rather on the principle of the parachute, merely floating the experimenter, who started from a moderate elevation, by a very gradual descent towards the earth.

FLYING FISH, a name given to several species of fishes which, by means of long fins, can sustain themselves for some time in the air. The common flying fish of the Mediterranean is thus able to raise itself so far above the surface of the sea as frequently to throw itself upon the deck of a ship; but the extreme limit of its flight is confined to an arch extending about 120 feet, when the drying of its fins necessitates its return to its proper element. See index to ICHTHYOLOGY.

FOAL, the young of the horse kind. The word *colt*, among dealers, is applied to the male, and *filly* to the female.

FOCHABERS, a village of Scotland, parish of Bellie, Morayshire, situated on the Spey, 4 miles from its mouth in the Moray Firth, and 9 miles E. of Elgin. It is neatly built; and in the vicinity is the magnificent domain of Gordon Castle, the property of the Duke of Richmond.

FOCUS, in *Geometry* and *Conic Sections*, is applied to a certain point in the parabola, ellipsis, and hyperbola, where the rays reflected from all parts of these curves meet. In *Optics*, a point in which any number of rays meet, after being reflected or refracted.

FŒTUS, the young of viviparous animals whilst in the womb, and of oviparous animals before being hatched. See ANATOMY, and PHYSIOLOGY.

FOG, or MIST See METEOROLOGY, and PHYSICAL GEOGRAPHY.

FOGGIA, a city of Naples, capital of the province of Capitanata, and situated near the centre of the great plain of Apulia, 80 miles E.N.E. of Naples. The town is well built; and the principal streets, which are wide and clean, contain some handsome houses and good shops. The cathedral, originally a stately Gothic edifice, was destroyed by an earthquake in 1731, and the upper part of it has been rebuilt in a different style, by which its effect is greatly injured. Foggia contains numerous other churches, a governor's palace, theatre, custom-house, and the remains of a palace which, together with a large well, was constructed by Frederick II. It is the seat of the provincial courts, and the centre of all the trade of the province, which, in spite of its ill-chosen and unhealthy situation, give it a more animated appearance than any other city in the kingdom except the capital. The corn magazines (fosse) are very extensive, consisting of vaults lined with masonry, extending under the principal streets and squares. Foggia is a staple market for corn and wool, and the place at which a toll is collected upon the numerous flocks of sheep that descend annually in autumn from the mountains of Abruzzo into the plains of Apulia, to avoid the cold of the high country. It is traversed by roads leading to Naples, Bari, Piscara, Bovino, Manfredonia, &c., and is thus the entrepôt of an extensive trade in agricultural and other produce. Pop. about 21,000.

FOGO, one of the Cape Verd Islands, lying W. of Santiago, in N. Lat. 14. 50., W. Long. 24. 34. It is about 40 miles in circumference, and is almost entirely occupied by a volcanic mountain, which rises to the height of upwards of 9000 feet. An eruption of this volcano took place in 1847, and caused great damage. The island is very fertile, and contains about 7000 inhabitants.

FOHR or FORA, an island of Denmark, lying off the coast of Schleswig, in the North Sea; N. Lat. 54. 43., E. Long. 8. 30.; area 25 square miles. The eastern part of the island, with a population of 2650, belongs to Schleswig; and the western, with 2100 inhabitants, to Jutland. The inhabitants are chiefly engaged in navigation, fishery, manufacture of hosiery, and the taking of wild fowl. The principal port is Wyk.

FOIL, in fencing, a kind of blunt sword, which is tipped with a button covered with leather.

FOIL, among jewellers, a thin leaf of metal placed under transparent stones in order to improve their colour or heighten their lustre. Foil also denotes the sheet of tin amalgam laid on the back of a mirror to make it reflect a perfect image. Coloured foils are prepared by covering thin sheets of copper, highly polished, with coloured varnishes.

FOIX, a town of France, capital of a cognominal arron-

dissement, and also of the department of Ariège, is situated on the left bank of the Ariège, in the gorge of a narrow valley, bounded by rocky and precipitous hills, 44 miles S. of Toulouse. It was the capital of the old Comté de Foix; and on an isolated rock, rising from amidst the houses, stands the old castle of the counts. It has three fine towers, all anterior to the fifteenth century, the tallest being 136 feet high. They are now used as a prison. Foix has a considerable trade in iron. Pop. (1851) 4110.

FO-KIEN, or FU-KIANI, a large province of China, bounded on the N. by Che-Kiang, E. by the Chinese Sea, S. by Kwang-Tung, and W. by Kiang-Si: estimated area, 53,480 square miles. This province is generally mountainous, particularly in the northern and western parts, where it is bounded by the high range of the Nanling. Its sea-coast is bold and rugged, but presents many capacious and secure harbours. Off the coast lie numerous islands, whose lofty granitic or trap peaks extend in precipitous barren headlands from Namoh as far as the Chusan Archipelago. The river Min, formed by the union of three large streams at Yenping-fu, drains about three-fourths of the province, or all that part of it lying east of the Wu-i hills, and empties itself into the ocean by several mouths. Tea, sugar, camphor, tobacco, and indigo are the chief articles grown for export. The population is estimated at 15,000,000.

FOKSCHAN, or FOKSCHANI, a town of European Turkey, on the Milkov, 92 miles N.N.E. of Bucharest. It consists of two parts, one of which belongs to Wallachia, the other to Moldavia; and has a considerable trade in cattle, corn, and other agricultural produce. Good wine is produced in the vicinity. Pop. 6000.

FOLARD, JEAN CHARLES DE, born on the 13th of February 1669 at Avignon, was a French military officer distinguished for his writings on tactics. His genius was roused by reading Cæsar's *Commentaries;* and at the age of sixteen he entered the army contrary to his father's wish. By the Duke of Vendôme, who commanded in Italy in 1702, he was intrusted with part of his forces; and so well did he acquit himself, that he was honoured with the cross of St Louis, and received a pension of 400 livres. In the battle of Cassano, in August 1705, he lost, by a wound, the use of his left hand; and in 1706 he defended Modena against Prince Eugene, by whom he was taken prisoner some time after the battle of Blenheim. In 1711 he was appointed governor of Bourbourg, and in 1714 helped to defend Malta against the Turks. Soon after this he entered the service of Charles XII. of Sweden, and accompanied him in the invasion of Norway; but returned to France, where he served as colonel under the Duke of Berwick. In his later years he applied himself to the study of military art, and died at Avignon in 1752. His works are: *Nouvelles Découvertes sur la Guerre*, 1724, 12mo; *Commentaires sur Polybe*, 1753, 7 vols. 4to; and *Fonctions et Devoirs d'un Officier de Cavalerie*, 1733, 12mo.

FOLCLANDS, or FOLKLANDS. Copyhold lands were so called in the time of the Saxons, as charter-lands were called *boclands*. *Fockland* was *terra vulgi* or *terra popularis*, the land of the common people, who had no certain estate therein, but held it under the rents and services accustomed or agreed, at the will only of their lord the thane; and it was therefore not put in writing, but accounted *prædium rusticum et ignobile*.

FOLCMOTE, or FOLKMOTE (Saxon, *folcgemote*, that is, *conventus populi*), is composed of *folk*, people, and *mote* or *gemote*, to assemble, and originally signified a convention of the people, to consult respecting public affairs. According to Spelman, the *folcmote* was a sort of annual parliament or convention of the bishops, thanes, aldermen, and freemen, which assembled upon every May-day, and in which the laymen were sworn to defend one another and the king, and to preserve the laws of the kingdom, after which they consulted of the common safety. But, from the laws of the Saxon kings of England, Dr Brady infers that it was an inferior court, held before the king's *reeve* or steward every month, to do *folk* right, or compose smaller differences; and that from it there lay an appeal to the superior courts. Squire seems to think that the *folkmote* was not essentially distinct from the *shiremote*, or common general meeting of the county. (See his *Angl. Sax. Gov.* 155, n.) Manwood mentions *folcmote* as a court holden in London, in which all the *folk* and people of the city did complain of the mayor and aldermen for misgovernment within the said city; and this word is still in use, denoting *celebrem ex tota civitate conventum.* According to Kennet, the *folkmote* was a common council of all the inhabitants of a city, town, or borough, convened by sound of bell, or otherwise, to the *Mote Hall* or *House;* or it was applied to a larger congress of the freemen within a county, called the *shiremote*, where formerly all knights and military tenants did homage to the king, and elected the annual sheriff on the first of October, until 1315, when, to avoid tumults and riots, this popular form of election was by 3d Edward I. merged in nomination by the king. After this time the city *folkmote* was swallowed up in a select committee or common council and the county *folkmote* in the sheriff's tourn and assizes.

The word *folkmote* was also used to signify any kind of popular or public meetings, as those of the tenants at the *court leet* or *court baron*, in which signification it was of a less extent than that above explained. (*Paroch Antiq.* 120.)

FOLDVAR, a town of Hungary, county of Tolna, on the right bank of the Danube, 50 miles S. of Buda. It is a steam-packet station, but is chiefly noted for its sturgeon-fishery. Pop. 10,000.

FOLENGO, THEOPHILUS, better known by his assumed name of *Merlin Cocajo*, an eccentric genius and burlesque poet, was descended of a noble family of Mantua, and born at a place called Cipada in the year 1491.[1] From his infancy he showed great vivacity of mind, and a singular facility of turning everything that occurred into verse. He completed his studies at Bologna, and at the age of sixteen entered the order of Benedictines of the congregation of Monte Cassino, near Brescia. He then assumed the name of Theophilus instead of Jerome, which was his baptismal name, and eighteen months afterwards he made profession as Benedictine. At first his life was regular; but he soon forgot his vows, and ended by quitting the monastery to stroll about with a young woman named Giron Dieda, who had captivated his fancy. With her he wandered about for ten years, with no other resource for procuring a livelihood than his talents and his verses. He had commenced a poem in Latin, which, as far as it went, displayed much elegance; but he soon quitted serious poetry, in which he could at most only hope to obtain a secondary rank, for a kind which he called Macaronic, in which he conceived himself qualified to occupy the first place. The basis of the language employed by him is Latin, mixed with Italian words, and still more with the Mantuan patois, which was his mother tongue, and to which he gave Latin terminations. In his

[1] Folengo, in his verses, has several times mentioned the place of his birth in his own peculiar vein:

Magna suo veniat Merlino parva Cipada.—
Mantua Virgilio gaudet, Verona Catullo,
Dante suo florens urbs Tusca, Cipada Cocajo.—
Nec Merlinus ego, laus, gloria, fama Cipadæ, etc.

poem he recounts the ridiculous adventures of a hero called Baldus, among which are several which had happened to himself; and under the mask of burlesque and buffoonery may be found thoughts and maxims instinct with good sense, not to mention original and piquant touches of satire on the conduct of the great, the vanity of titles, and the different pursuits of men. Instead of dividing his poem into books or cantos, he divided it into macaronis (*macaronea prima*, *macaronea secunda*, etc.), of which there were seventeen in the first edition and twenty-five in the subsequent ones; and he published the whole under the name of *Merlinus Cocajus*, which afterwards became famous. In a few years several editions were published; but the success of these facetious productions did not prevent their being bitterly criticised. The author was severely censured, both for the style and the license of idea and expression in which he indulged; a circumstance which irritated him so much that, changing language and name, he composed in three months a satirical Italian poem, in eight cantos, on the infancy of Roland, to which he gave the title of *Orlandino*, and affixed the name of *Limerno Pitocco; Limerno* being the anagram of *Merlino*, and *Pitocco* or *mendicant* being significative of the state to which he was occasionally reduced. He had nevertheless made many friends in the world by the reputation which he had acquired, the extent of his knowledge, and the agreeable qualities of his mind; and he had even retained some in the cloister, into which, when tired of a wandering and miserable life, he was received back with open arms. He signalized his return by a work on the subject of his conversion, entitled *Il Chaos del Triperuno*, or The Chaos of Three for One, meaning himself, who had been successively Theophilus Folengo, Merlin Cocajo, and Limerno Pitocco. The work is a medley of verses, songs, and narrations, in Latin, Italian, and the Macaronic dialect, in short, a veritable chaos, divided into three parts, called, after Statius, *Sylvæ*. Folengo appears to have remained during several years at Capri, a country house belonging to his order, between Brescia and Bergamo, and to have divided his time between this retreat and Brescia till 1536 or 1537, in one or other of which years he composed his Italian poem on the Humanity of the Son of God, the most orthodox of all his works, and which would be the most edifying if one could really be edified by that which is unreadable. He was then sent into Sicily to the monastery of St Martin delle Scale, where he appears to have remained till 1543, when he returned into Italy, and retired to the convent of the Holy Cross of Campesa, near Bassano, on the banks of the Brenta, where he died in little more than a year afterwards, 9th December 1544, in the fifty-third year of his age.

FOLIATING OF LOOKING-GLASSES, the process of covering the glass with amalgam, in order that it may reflect the image. The method, as practised at the largest looking-glass manufactory in Britain, at St Helen's in Lancashire, is as follows:—On a smooth and level table of stone or iron with a slightly elevated border, mercury is poured in a thin stratum: the mercury is covered with tinfoil; and the glass-plate, previously well cleaned, is slowly slid along the metallic surface, so as to exclude air-bubbles: weights are then placed on the glass, to make its contact with the amalgam of tin and mercury more complete. The amalgam soon adheres to the plate, which is then raised on its edge to allow the superfluous mercury to drain off. It is then carried to the *drying-room*—and the process is complete.

FOLIGNO, the ancient *Fulginium*, a town of the Papal States, delegation of Perugia, on the Topino, 20 miles S.E. of Perugia. This is an active and industrious town, and has manufactures of woollens, paper, parchment, and wax candles. It has a cathedral and numerous churches, some of which contain fine paintings. During the middle ages it for a long time maintained its independence, but was at length reduced by its more powerful neighbours; and in 1439 was incorporated with the States of the Church. Pop. 9000.

FOLIO, a book of the largest size, formed by once doubling a sheet of paper. It is also applied to the opposite pages of an account-book, expressed by the same figure.

FOLKES, MARTIN, an eminent English antiquary, was born at London in 1690. At the age of seventeen he was entered of Clarehall, Cambridge, where he distinguished himself so much in mathematics, that when only twenty-three years of age he was chosen a fellow of the Royal Society. Newton, the president of that body, secured his election as one of the vice-presidents; and on the death of that great philosopher, Folkes became a candidate for the presidency, but without success, as the higher standing and superior influence of Sir Hans Sloane carried the election against him. In 1733 he set out on a tour through Italy, in the course of which he composed his admirable "Dissertations on the Weights and Values of Ancient Coins," which he read before the Society of Antiquaries. Before that same body he read in 1736 his "Observations on the Trajan and Antonine Pillars at Rome," a work which was afterwards printed. In that same year he communicated to this same society his "Table of English Gold Coins from the 18th year of King Edward III., when gold was first coined in England, to the present time, with their Weights and Intrinsic Values;" and in 1745 he printed this work along with another on the history of silver coinage. In 1741 Folkes succeeded Sir Hans Sloane as president of the Royal Society; in the following year he was made a member of the French Academy; and 1746 was honoured with the degree of LL.D. from Cambridge and Oxford. He died in 1754.

FOLKESTONE, or FOLKSTONE, a municipal borough, seaport, and market-town of England, county of Kent, 7 miles W.S.W. of Dover, of which it is a sub-port. It is governed by a mayor, 4 aldermen, and 12 councillors, and is included in the parliamentary borough of Hythe. At an early period this was a place of some importance, and since the opening of the South-Eastern Railway it has been rapidly increasing. It is situated in a hollow between two precipitous chalk cliffs, and is irregularly built. The parish church is a cruciform structure in the early Gothic style, with a tower rising from the intersection. There are several Dissenting chapels, a grammar-school, market-house, and baths. It is frequented in summer for sea-bathing; and many of the inhabitants are engaged in the fisheries. The coast is defended by three martello towers; and a strong modern battery, situated on the heights, protects the town. The pier-harbour is 19 acres in extent, and has recently been much improved by the removal of shingle at its mouth, so as now to admit vessels of 150 tons burden. The South-Eastern Railway is here conducted over a magnificent viaduct; and steam-packets ply daily between this town and Boulogne. On 31st December 1853, 14 vessels of 1037 tons were registered as belonging to the port, and during that year 305 sailing vessels of 30,350 tons, and 431 steam vessels of 64,781 tons, entered; and 9 sailing vessels of 719 tons, and 429 steam vessels of 64,638 tons, cleared at the port. In 1847 the custom-house receipts amounted to only L.4008, and in 1852 had increased to L.122,133. This town has suffered much at different periods from encroachments of the sea. Harvey, the discoverer of the circulation of the blood, was born here in 1578. Market-day, Thursday. Pop. (1851) 6726.

FOLLICLE (*follis*, a bag), in *Botany*, a carpel that opens longitudinally by the ventral suture, and of which the pericarp is not fleshy, but usually foliaceous. There are generally many follicles in the same flower. It is also applied to a vessel distended with air; as on the leaves of aldrovanda.—In animal bodies, a gland, folding, or cavity.

FOMALHAUT, a star of the first magnitude, in the constellation PISCIS AUSTRALIS; rt. ascen. (1856) 22:49:41: decl. 30:23:3·7, with annual var. = + 3·33 seconds.

FONDI, the ancient *Fundi*, a town of Naples, province of Terra di Lavoro, 14 miles N.W. of Gaëta. This is now a wretched town of about 5000 inhabitants, and only remarkable for the remains of the ancient city. The Appian Way passes through the town, and constitutes its principal street, the ancient pavement being still almost entire. Remains of the cyclopean walls, and of numerous ancient buildings, are still to be seen. The cathedral is a very ancient Gothic edifice. Fundi was celebrated among the Romans for the excellence of its wines, and the famous *Cæcubus Ager* was in the vicinity. The town is very unhealthy from proximity to the *Lacus Fundanus*.

FONT (*fons*), a vessel used in churches to hold water for the purpose of baptism, and also for holy water in Roman Catholic churches. Many of the English fonts are curious both for their antiquity and their elaborate architectural embellishments.

Font or Fount (*fondre*, to cast), in *Printing*, a complete assortment of printing types of one size, including the running letters, large and small capitals, points, numeral characters, &c. See Type-Founding, and Printing.

FONTAINE, Jean de La, the celebrated French fabulist, and one of the greatest of French poets, was born in 1621 at Château-Thierry in Champagne. His father was Maître des Eaux et des Forêts in that town, and had little time to bestow on the education of his son, who did not exhibit a spark of intelligence till he had reached his twenty-second year. At Rheims, where he got all the education he ever received, he devoted himself more to pleasure than to study, and in after days described in flowing and melodious verse the gallantries of which he had then been guilty. In 1641 he entered the monastery of the Oratoire, but finding the monkish way of life extremely distasteful, he left it and returned home. Soon after this he married and succeeded his father in his office, performed his duties extremely ill, and finally abandoned his wife (with whom he had lived on very indifferent terms) to go to Paris in the train of the Duchess de Bouillon, niece of Cardinal Mazarin. Before this time, however, his mind had begun to awaken to a consciousness of its strength. An ode of Malherbe, which was once read in his hearing, is said to have elicited from him the expression, "I too am a poet," and to have first stimulated him to literary enterprise. He began a systematic study of the writers of his own country and of the ancient classics, and the first-fruits of his labours was a translation of the "*Eunuchus*" of Terence. This work had very poor success, and was in many respects so unsatisfactory as not to deserve much. In the French metropolis La Fontaine was kindly received, and spent much of his time and far more money than he could afford in the pursuit of those pleasures for which that city affords unrivalled facilities; but none of the reverses of fortune by which he was overtaken ever altered his disposition in the least. His indifference to his worldly affairs compelled him to sell year by year a portion of his patrimonial estate, and it is not known to what straits he might have been reduced had not a charitable lady, Mme. de la Sablière, received him into her house, and taken care of him for twenty years. When driven by her own necessities to reduce her establishment, this lady used to talk to her friends of having retained only her three animals—her dog, her cat, and La Fontaine. In 1684 La Fontaine was admitted into the French Academy, but Louis XIV., indignant that he should have been preferred to Boileau, refused to sanction his appointment. Another vacancy occurring soon after gave an opportunity for Boileau's election, and both candidates were admitted without any opposition from the king. On the death of Mme. de la Sablière, La Fontaine was reduced to great extremities, and had seriously bethought himself of going to England on the invitation of St Evremond. Luckily, the kind intervention of the Duke of Burgundy in his behalf enabled him to remain at home. His health at this time became very bad, and was not much improved by his squabbles with the clergy, who, believing him to be dying, threatened him with the terrors of the church unless he made a public apology for his licentious tales, and burned a comedy which he was preparing for the stage. After a good deal of hesitation, he complied with both these demands. In 1693 his health became rapidly worse, and he spent the most of his time in translating hymns for the church and in other literary exercises, chiefly of a religious character. His last days were cared for by the kindness of his friend D'Hervart, who received him into his house and tended him with almost filial care till his death in 1695.

The character of La Fontaine is a curious medley of strength and weakness. His acute perception of what was right, and his inability to practise it, remind us of Richard Steele. His invincible laziness and good-humour are only to be paralleled by the similar qualities in the author of *The Seasons*. His shrewd yet childlike simplicity, his vanity, his tenderness of heart, his awkwardness, and his absence of mind, are all qualities which he had in common with our own Goldsmith; and indeed, the epithet of "inspired idiot," unjustly applied to that author, might with much propriety have been given to the French fabulist. His weaknesses were all of a kind that made him at once the pet and the laughing-stock of his friends. With Racine, Molière, and Boileau he lived on terms of the most intimate friendship. They often rallied him, and sometimes with good reason, on his many failings; but as Molière said on one of these occasions, "Ils ont beau se trémousser, ils n'effaceront pas le bonhomme." The sobriquet of "Le Bonhomme" was so pat that it stuck to him through life, and has been confirmed by posterity. He often exhibited the strangest want of interest in matters of the deepest concern, and a dreamy absorption in trifles, such as seemed to argue some unaccountable intellectual weakness. Possessed as he undoubtedly was of rare and remarkable literary powers, his range both of sympathy and knowledge in literary affairs was astonishingly limited. On one occasion hearing Racine read some extracts from Plato, he suddenly broke out into a rhapsody of admiration for the Greek philosopher, whom he praised as one of the most amusing of writers. At another time, being present at a theological debate that was carried on with much spirit, he fell asleep, and on awakening asked the company whether they thought that St Augustine was as witty a writer as Rabelais. Racine once took him to the "Tenebræ," and seeing that he was wearied by the length of the performance, put a Bible into his hands. La Fontaine opened it at the book of Baruch, and was so much struck with what he there read that he could not help crying out to his companion, "This Baruch is a very fine writer; do you know anything of him?" And for several days after he asked everybody that he met, "Have you ever read Baruch? He's a man of first-rate genius. Do you know who he was?" One day he met his own son, whom he did not recognise, and remarked to him that he was a lad of parts and spirit. Being told that the youth was his own son, he merely observed that "he was very glad to hear it." In 1693, when he was believed to be dying, Poujet, vicar of St Roch, brought him the New Testament. He read it, and assured his friends "Je vous assure que c'est un fort bon livre; oui, par ma foi, c'est un fort bon livre."

As an author, La Fontaine will be best known to posterity by his Fables. He published other works, of which the best known are his "*Contes*" or Tales, the first volume of which appeared in 1664, the second in 1671. These abound in fine touches of his genius, but are polluted with such a taint of gross license and indecency that they are now seldom read even by his own countrymen. As a

fabulist, however, La Fontaine has never had his equal either in ancient or modern times. He has, indeed, little or no originality of invention, for most of his tales are taken from Boccaccio, Ariosto, Machiavelli, and others; and Æsop has suggested the idea of the great majority of his fables. His reflections are not remarkable either for depth or novelty, and he displays an almost total incapacity for continuous thinking; but his manner of telling his stories is quite inimitable, and in that lies the principal charm of his writings. 'His narrative,' as has been remarked by Laharpe, 'is distinguished by that ease and grace which are to be perceived, not described; for if after a profound philosophical investigation we arrived at the ultimate causes of excellence, and referred the matter to La Fontaine himself, the 'bonhomme' would say "I know nothing about all this; I wrote as my humour dictated, and that was all."' The rapidity of his transitions from the most sparkling wit to the most touching pathos, his occasional gleams of the finest humour and fancy, and his delicate touches of observation, are all enhanced by a diction simple and refined, and presenting in almost every line some happy turn of expression, or some graceful naïveté of sentiment. (For a detailed analysis of La Fontaine's fables, see art. FABLE.)

There have been many editions of the *Fables*, of which the most sumptuous is that of 1755–59, in 4 vols. fol. La Fontaine's other works are *Les Amours de Psyché*, a romance; *Le Florentin*, a comedy; *L'Eunuque*, a translation from Terence; *Anacréontiques*, *Lettres*, and some pièces d'occasion, published collectively in *Les Œuvres diverses de La Fontaine.*

FONTAINEBLEAU, a town of France, capital of an arrondissement in the department of Seine-et-Marne, is distant about 37 miles in a S.E. direction from Paris, on the lines of high road and railway that connect that city with Lyons. Pop. of commune (1851) 8278. The town stands in the midst of the Forest of Fontainebleau (which is nearly 64 square miles in extent); is well-built, and has some wide and handsome streets. It possesses a college, excellent barracks for cavalry, hospitals of various kinds, public baths, and a good public library. In the immediate vicinity of the town is the celebrated palace—one of the largest, and interiorly one of the most sumptuous of the royal residences in France. The kings of France are known to have had a palace at Fontainebleau as far back as the year 1169; and this palace was a favourite abode of Louis VII., Philippe-Auguste, and St Louis. The existing building was begun by Francis I., who laid out immense sums of money upon it. Primaticcio, a famous Italian architect, was instructed to draw out the plans of it; while such artists as Leonardo da Vinci, Andrea del Sarto, and Benvenuto, were commissioned to expend upon it all the resources of their various arts to make the place a truly royal residence. The edifice was completed as it now stands by Louis XIV.; but after his death it fell into disfavour, and was used for a while as a military school. Napoleon restored it with great splendour, and often resided in it; but after the Restoration it was allowed to fall into disrepair. Louis-Philippe expended immense sums of money upon it; and in point of internal decoration it is now inferior to none of the French palaces.

Many events of importance have taken place at Fontainebleau. Philippe-le-Bel, Henri III., and Louis XIII. were all born in the palace, and the first of these kings died there. Henri IV., who greatly improved and embellished it, made it his favourite residence; as did also his daughter, Henriette, widow of Charles I. of England. Christina, the self-exiled queen of Sweden, lived here; and one of the galleries is still shown as the spot where she caused her unfortunate secretary, Monaldeschi, to be murdered. In 1685 the revocation of the Edict of Nantes was signed here; and in the following year the great Condé closed his career in the very room in which the eldest son of Louis XV. afterwards died. Pope Pius VII. was here confined prisoner for a year and a half by Napoleon; and in 1814 the emperor took leave of his guard, and signed his abdication of the French throne at Fontainebleau. The present emperor of the French sometimes resides here to enjoy the sports of the forest, which is well stocked with game of various kinds, especially wild boars. The beautiful gardens and ornamental waters immediately surrounding the palace form a great attraction to the Parisians, large numbers of whom arrange parties of pleasure to Fontainebleau during the summer months, especially on Sundays.

FONTAINES, PIERRE FRANÇOIS GUYOT DES (1685–1745), a French critic of considerable note. He was a member of the Society of Jesus, and held various ecclesiastical appointments, but at the age of thirty he renounced the church and devoted himself to literature. In 1724 he became editor of the *Journal des Sçavants*, which he did much to rescue from the discredit into which it had fallen. From the imputation of an infamous crime for which he was imprisoned he was saved by Voltaire; though between him and his benefactor there afterwards broke out one of the most bitter and disgraceful literary quarrels on record. Des Fontaines constituted himself the leader of an anti-Voltairean movement, and reviewed some of Voltaire's works with unjustifiable severity. That author retaliated, and exerted all his influence, political, literary, and social, to ruin his quondam friend. Even after Des Fontaines' death Voltaire strove to tarnish his memory, and held him up to ridicule in *Le Pauvre Diable.* Des Fontaines, however, had some of the qualities of a good critic. He possessed a solid judgment, quick insight, and very considerable learning. But he was neither impartial nor disinterested, and, as a writer, is little above mediocrity. His principal works are a prose-version of the *Æneid;* translations of various works of Swift and Pope; and some novels deservedly forgotten. He also contributed largely to the *Journal des Sçavants*, the *Nouvelliste du Parnasse*, and other periodicals.

FONTANA, FELICE, a distinguished physiologist and experimental philosopher, born at Pomarolo, a little town in the Tyrol, on the 15th April 1730. He began his studies at the neighbouring city of Roveredo, and continued them in the schools of Verona and Parma, and afterwards in the universities of Padua and Bologna. He then visited Rome, and went to Florence, where he obtained from the Emperor Francis I. who was at that time Grand Duke of Tuscany, the appointment of professor of philosophy at Pisa; but the Grand Duke Peter Leopold, who was also afterwards emperor, invited him to settle at Florence, and gave him an establishment connected with his household, as *Fisico* or naturalist, and as director of the cabinet of natural history, which was afterwards rendered by his exertions one of the principal ornaments of the city of Florence.

Fontana wrote many works on physiology, natural philosophy, and chemistry. In 1757 he was engaged in an investigation tending to confirm the doctrines of Haller respecting the irritability of the muscles, considered as a distinct quality inherent in those organs. Haller has published several of his letters as a part of his own *Mémoires sur les parties sensibles et irritables;* and the subject afforded Fontana the materials of several successive essays—*De Irritabilitatis legibus nunc primum sancitis*, Atti di Sienna, vol. iii., p. 209, 1767; *Ricerche filosofiche sopra la Fisica animale*, 4. Flor. 1775. This volume contains only the *Essay on the Laws of Irritability*, stating, first, the general outline of the doctrine, then entering into the different intensity of the property of irritability, and its loss by exhaustion or by inactivity, and discussing the action of the heart, and the peculiarities of death occasioned by electricity. Another link of the same chain of investigation is found in the earlier publication, *De' moti dell' Iride*, 8. Lucca, 1765; showing that the contraction of the pupil depends on the

Fontana. effect of light falling on the retina, and not on the iris itself, and establishing an analogy between the motions of the uvea and the semi-voluntary actions of the muscles of respiration. One of the most important of Fontana's works is his *Ricerche fisiche sopra 'l Veneno della Vipera*, Lucca, 1767; containing an immense multitude of experiments calculated to show that the poison of the viper acts by mixing with the blood, and destroying the irritability of the muscles to which it is conveyed; but that the bite of the *Vipera aspis*, though fatal to small animals, is scarcely ever capable of producing any immediately dangerous effects on the human frame. The same matter was republished with many additions in the *Traité sur le Vénin de la Vipère, sur les Poisons Américains, sur le Laurier-cérise, et sur quelques autres Poisons*, Berlin, 1787; together with some observations on the primitive structure of the animal body, experiments on the reproduction of the nerves, and remarks on the anatomy of the eye. In 1766 our author published an essay entitled *Nuove Osservazioni sopra i globetti rossi del sangue*, Lucca; confuting the assertions which had lately been advanced by Della Torre respecting the complicated structure and changes of form of the globules of the blood. In the next year appeared *Osservazioni sopra la ruggine del grano*, Lucca, 1767; describing an animalcule like an eel, to which he attributes the rust of coin, but which has not always been found by subsequent observers in similar cases, perhaps for want of accurate distinction. There is also a *Lettre sur l'Ergot, Journ. Phys.* vii., p. 42. The *Lettera sopra le Idiatidi e le Tenie, Opuscoli Scelti.* vi., p. 108, Milan, 1783, contains an account of the hydatids which produce the symptoms of vertigo in sheep. A *Lettre à* M. * * *, *Journ. Phys.* vii., p. 285, contains some remarks on the circulation of the sap in plants. In an essay *Sur le Tremella, Journ. Phys.* vii. p. 47, a zoophyte of a green colour, described by Adanson and others as a plant, is shown to consist of a multitude of little animals in continual motion.

Fontana entered also very minutely, but with more industry than accuracy or closeness of reasoning, into the chemical novelties which occupied so much attention throughout Europe in the latter half of the last century. He seems, however, to have had the merit of first applying the discoveries of Priestley respecting the effects of the nitric oxide to the examination of the qualities of the atmosphere by means of the eudiometer, which is the subject of his *Descrizione e usi di alcuni Stromenti per misurar la salubrità dell' aria*, 8. Flor. 1774, 4to, 1775, and is further illustrated in his *Recherches physiques sur la nature de l'air dephlogistique et de l'air nitreux*, 8. Par. 1776. He also observed the remarkable property that charcoal possesses of absorbing several times its bulk of different gases. In the *Ricerche fisiche sopra l'aria fissa*, 4. Flor. 1775, he is by no means equally fortunate, having fancied that the acidity of the fixed air is not essential to it, but accidentally derived from the stronger acid employed in expelling it from the earth or alkali. The *Philosophical Transactions for* 1779, p. 187, contain his *Experiments and Observations on the Inflammable Air breathed by various Animals*, consisting of a repetition of Scheele's attempt to breathe hydrogen gas, which did not always create a sensation of immediate uneasiness, though it was sometimes productive of alarming consequences. In the same volume, p. 432, we find an interesting *Account of the Airs extracted from different kinds of Waters, with thoughts on the Salubrity of the Air at different places*, showing that the air afforded by water is very different under different circumstances, but that the quality of the atmosphere itself scarcely ever exhibits any variations which can be rendered sensible by chemical tests.

To the Memoirs of the Italian Society Fontana contributed several short essays; the first, entitled *Principi generali della solidità e della fluidità dei corpi*, vol. i., p. 89, Verona, 1782, containing the prevalent theories of the day respecting the change in the forms of aggregation of the same substance, together with experiments on the elasticity of different gases. The second is a collection of definitions, entitled *Sopra la luce, la fiamma, il calore e il flogisto*, p. 104, characterizing these supposed elementary principles according to the ideas of Bergman, Scheele, and others. In a later volume, v. p. 581 (1790), we find a *Lettera del Cavaliere F. Fontana al Sign. de Morveau*, in which it is conjectured that inflammable air may be a compound of phlogiston and water, and it is observed that the white crusts of flints contain as great a proportion of pure silica as their internal parts. Our author remarks, however, that his attention had of late been much distracted from chemical pursuits by the attention required for the completion of his collection of wax models of anatomical subjects, and for the duplicates which he was preparing for the cabinet of Vienna at the request of the emperor. At a subsequent period another series of copies of these models was ordered by Bonaparte to be sent to Paris; but it was there judged inferior to the preparations already existing in the Ecole de Médécine, which had been made under the direction of Laumonier, and Fontana's collection was sent to the university of Montpellier. He was latterly engaged for some time in the preparation of a colossal model of a man, built up anatomically of all his component parts, which were accurately represented in wood; but this elaborate design was never completed.

Fontana was also the author of a few other chemical and mineralogical papers of less importance. His last work is entitled *Principes raisonnés de la Génération.* He was also meditating an essay on the revivification of animals, but he did not live to complete it. A collection of his works, translated into French by Gibelin, was published at Paris in 1785, entitled *Observations Physiques et Chimiques.* Fontana died March 9th 1806, and was buried in the church of the Holy Cross, not far from the tomb of Galileo. (Cuvier, in *Biographie Universelle*, vol. xv. 8. Par. 1816.) (T. Y.)

FONTANA, *Gregorio*, a profound mathematician and natural philosopher, younger brother of Felice Fontana, was born at Villa de Nogarola, near Roveredo, on the 7th December 1735.

He received the first rudiments of his education at Roveredo, and continued his studies at Rome, where he entered into the *Scuole Pie*, and soon distinguished himself by his talents and assiduity. He was entrusted with the care of a part of the public instruction in the school called the Collegio Nazareno, and was soon afterwards sent as a professor to Sinigaglia. It was here that he formed an intimacy with the Marquis Fagnani, whose example and assistance contributed very much to the advancement of his mathematical studies, to which he very soon in a great measure confined his attention. He was then removed by his superiors to Bologna; but his co-operation was found more necessary for the pious schools which had lately been established at Milan, and he there obtained the patronage and friendship of the Count de Firmian, the Mæcenas of the day, who greatly encouraged the publication of his first works. From these works he acquired so much credit, that he was summoned in 1763 to occupy the chair of logic and metaphysics in the university of Pavia; and he was appointed by Firmian director of the public library which he founded about the same time for the university. Two years afterwards he was advanced to the professorship of the higher mathematics, which had become vacant by the death of the celebrated Boscovich, and he filled this situation with high reputation for thirty years. In April 1795 he was elected a foreign member of the Royal Society of London. About this time his health began to decline, and his physicians considered him as having suffered from too great application to his studies. In 1796 he received great marks of respect from Bonaparte, then commanding the French

army in Italy; and he was made a member of the legislative body of the newly erected Cisalpine republic. In 1800, having resigned the professorship at Pavia, he came to Milan, and was afterwards nominated one of the Electoral College of the Dotti. He was still occupied in a variety of literary pursuits, when he was attacked by a violent fever, which caused his death at Milan, on the 24th August 1803.

Fontana's principal publications were seven Academical Dissertations on various departments of mathematical and mechanical science; a great variety of papers in the *Memoire della Società Italiana delle Scienze;* and numerous translations. (T. Y.)

FONTARABIA. See Fuente-rabia.

FONTENAY, or Fontenai, the capital of a cognominal arrondissement in the department of Vendée, France, is situated on the river Vendée, at the point where it becomes navigable, 35 miles S.E. of Bourbon-Vendée. The town is old and generally ill-built. It was formerly fortified and still has some remains of its castle, which belonged to the counts of Poictiers. The only remarkable object is the parish church, which has a spire 311 feet in height. It has manufactures of course linen and woollen cloths, and a considerable trade in timber and wines. Pop. (1851) 7348.

FONTENELLE, Bernard Le Bovier de, author of the *Eloges, Dialogues des Morts,* &c., was born at Rouen, Feb. 11, 1657, died at Paris Jan. 9, 1757, having very nearly attained the age of 100 years. His father was an advocate settled in Rouen; his mother was a sister of the great Corneille. He was educated at the college of the Jesuits in his native city, and distinguished himself by the extraordinary precocity as well as the amazing versatility of his talents. His teachers, who readily appreciated his abilities, were anxious to allure him into their order, but his father designed him for the bar, and he became an advocate. He lost the first cause which was entrusted to him to plead, and immediately after abandoned law for the more congenial pursuits of literature. In 1674 Fontenelle visited Paris for the first time, and began his literary career as a poet. He competed for three of the prizes offered by the French Academy for the best poems on certain prescribed subjects, but without success, despite the powerful influence brought to bear on his behalf. He had the additional misfortune to see his tragedy of *Aspar* damned, though, for the purpose of annoying Racine, his uncle Thomas Corneille had already sounded forth his praises in the *Mercure* as the most gifted of the rising dramatists of France. Fontenelle afterwards acknowledged the justice of this sentence by burning his unfortunate drama, of which nothing but the name now survives. Still undaunted by his failures, he persisted in the belief that poetry was his true vocation, and produced a number of operas and comedies, the mediocrity of which, considering the author's real talent, is positively astonishing. His opera of *Thétis et Pelée,* though highly praised by Voltaire, is little superior to the others. Of all his dramatic works, seventeen in number, not one has kept the stage. His *Poésies Pastorales,* with equally small claim to permanent repute, are striking from their novelty and the extravagant conceits in which they abound. They exhibit neither sentiment nor nature; the shepherds are all *bergers de salons.* His Hylases and Sylvanders speak like the wits of the Hôtel Rambouillet. The utmost that can be said for his poetry in general is that it displays much of the *limæ labor,* great purity of diction, and occasional elegance and elevation of sentiment. The *Dialogues des Morts,* Fontenelle's first real title to literary renown, was published in 1683. This was a remarkable work for the era in which it appeared, and contains much fine and ingenious thinking, along with much that is wire-drawn and paradoxical. Three years later (1686) appeared his *Entretiens sur la pluralité des Mondes,* which, in the words of D'Alembert in the general preface to the *Encyclopédie,* was the first work "qui ait appris aux savants à secouer le joug du pédantisme." Voltaire pronounced it "le premier exemple de l'art délicat de répandre les graces jusque sur la philosophie," and, in the verses which he afterwards wrote on its author, characterized its happy combination of science and wit in the line—

"L'ignorant l'entendit, le savant l'admira."

It was precisely such a work as Fontenelle was capable of executing well, both from the natural bent of his intellect, and the course of his previous studies. His object was to popularize among his countrymen the astronomical theories of Descartes, and it is to be doubted if that philosopher ever ranked a more ingenious expounder among the number of his disciples. The pointed and happy illustrations with which Fontenelle has interspersed this essay are as amusing as they are instructive to the reader, and though some of the ideas advocated in it are rather startling, and sometimes quite opposed to received opinion, they are so plausibly stated, and set in so obvious a light, that they are at once adopted as old and familiar truths. In 1687 Fontenelle published his *Histoire des Oracles,* a book which made a considerable noise in the theological as well as the philosophical world. It was not so much an original work as a redaction from the Latin of Van Daale, and consisted of two essays, the first of which was designed to prove that oracles were not given by the supernatural agency of demons; and the second, that they did not cease with the birth of Christ. The clearness and precision of the style, and the naturalness and regularly progressive flow of the reasoning in this treatise, have been always much admired. It excited the suspicion of the church, however, and a Jesuit, by name Baltus, published a ponderous refutation of it; but the peace-loving disposition of its author impelled him to leave his opponent unanswered.

In 1691 Fontenelle was received into the French Academy in spite of the efforts of Racine and Boileau, who on four previous occasions had secured his rejection. In 1708 appeared the first edition of his *Eloges historiques des Académiciens,* the work by which he is best known to posterity. In these *Eloges,* which are at once biographical and critical, the author has so happily blended history and encomium that the formal character of the composition is quite lost sight of, and the eulogy is managed with such delicate tact that it is greatest where it seems least intended.

The only other works of Fontenelle that remain to be mentioned are his *Géométrie de l'Infini,* and his *Apologie des Tourbillons,* treatises which display rather a calm spirit of philosophy than strong scientific powers.

Fontenelle is likely to be remembered by posterity as much from his splendid social qualities, and the brilliancy and variety of his acquirements, as from the enduring value of his works. He combined in a singularly happy degree the philosopher and the man of fashion. As a writer, he strikes at first sight by his universality. Voltaire pronounced him the only universal man of the seventeenth century. He was in his own era very much what that writer was in the subsequent one. Without the restless energy and martyr spirit that distinguished Voltaire, Fontenelle nevertheless achieved noiselessly a great result. The vast extent of his reading gave him a thorough command of happy and pertinent illustration; and the perfect clearness and definiteness of his views on every department of science, joined to his high literary powers, enabled him to throw open to the multitude the gates of science, which till his day none but the scholarly few had possessed the secret of unlocking. This result was attained in a manner so simple and so noiseless that it did not appear to be the work of any individual agency so much as the natural growth of circumstances. Though Fontenelle cannot claim the merit of having made any great discovery, or contributed to the general store of positive knowledge, yet he sowed the seeds of that spirit of

free inquiry into the principles of religion, politics, and morals, which sprang up at the close of the seventeenth century, and which (in some departments at least) have not yet attained their full bloom and verdure.

Fontenelle's mind was eminently well-balanced. He was at once bold and circumspect, cool in temperament yet with wide sympathies, independent but not strongly opinionative; in a remarkable degree, as Voltaire remarked, *discreet.* In theory he was an egotist, in practice a man of much benevolence, and his large means enabled him to do a great deal of good with very little noise. He used to boast of being worse than he really was, and though his actions always belied his words, he has had the misfortune to be more generally judged by his words than his actions. He was perhaps the first man that ever said on the approach of death that if he had his life to live over again he would do exactly as he had done before. On his death-bed he consoled himself by remarking "I am a Frenchman; I have lived a hundred years, and I never threw the slightest ridicule on the smallest virtue." The calmness with which he met his death was in keeping with the serenity of his life. He merely observed, "Je ne souffre pas, mes amis; mais je sens une certaine difficulté d'être."

There have been several collective editions of Fontenelle's works, the best of which are those of Paris, 8 vols. 8vo, 1764; and 5 vols. 8vo, 1825. Some of his separate works have been very frequently reprinted.

FONTENOY, a village of Belgium, province of Hainault, five miles S.E. of Tournay, and celebrated for the victory gained there, in 1745, by the French under Marshal Saxe, over the allies commanded by the Duke of Cumberland.

FONTEVRAULT, *Order of,* a religious order instituted about the end of the eleventh century, and taken under the protection of the holy see by Pope Pascal II. in 1106, confirmed by a bull in 1113, and invested by his successors with very extraordinary privileges. This order, which consisted of both monks and nuns, was under the superintendence of an abbess. The order was divided into four provinces, which were those of France, Aquitaine, Auvergne, and Bretagne, in each of which they had formerly several priories. In 1804 this ancient abbey was converted into a prison.

FONTINALIA, in *Antiquity,* a festival celebrated by the Romans on the 13th October in honour of the deities who presided over springs and fountains.

FOOD.

THE subject of human food may perhaps be most conveniently considered under the following five heads:—

I. The chemical composition and the physiological action of the various proximate principles of animals and vegetables commonly employed as food. II. The varieties of animals and vegetables used as food in this country, the different alimentary products obtained from them, and their various composition. III. The modes of preparing food for use, and the *rationale* of their respective actions. IV. The modes of preserving articles of food from decomposition. V. The principles of diet, and some dietary tables.

I. *The chemical composition and the physiological action of the various proximate principles of animals and vegetables commonly employed as food.*

The different proximate principles (*i.e.*, specific unions of some of the elementary bodies of chemistry[1]) of animals and vegetables that may be used as food, and become converted into blood for the purpose of keeping up in adults the constant waste of the tissues, and for the same purpose and also for affording the additional matter that is required in growing individuals, have been, since the publication of Dr Prout's treatise, usually arranged into three classes and water. These three classes are—the saccharine, the members of which are composed of carbon, hydrogen, and oxygen, the two latter being combined in the same proportion that they are in water; the oleaginous, which likewise consists of the same elements, but in which the hydrogen and oxygen are not in the same proportion that they exist together in water; and the albuminous, which are essentially composed of the four elements of carbon, hydrogen, oxygen, and also nitrogen, the last-named element being almost invariably in the proportion of about fifteen per cent. But, besides these four elements, the human body, and therefore the nutritious parts of animals and vegetables that keep up that body, contain, although in small proportions, sulphur, phosphorus, sodium, chlorine, &c. The manner in which these elementary bodies are, in animal and vegetable structures, combined, is certainly not ascertained, and the subject will be partially considered by-and-by, when noticing Mulder's theory of proteine compounds, but they may, for all practical purposes, be stated to be combined with the albuminous proximate principles.

A. *Saccharine proximate principles derived from vegetables.*—1. *Cellulose.* The basis, or skeleton, as it were, of vegetable structures, is either cells, or vessels that are in fact composed of a number of ruptured or elongated cells. The walls of these cells are composed of the proximate principle under notice—cellulose. In order to separate it from the other constituents of the vegetable, it is necessary to cut the stem into small bits and digest them (for the purpose of separating the other constituents of the wood) successively in alcohol, ether, potassa water, hydrochloric acid, and water. Cellulose is not soluble in any of these, while the other constituents of the stem are, and hence cellulose is left behind. It is a white substance, but is changed into a violet colour if iodine be added to it. Its composition[2] is as follows: 24 atoms of carbon, 21 of hydrogen, and 21 of water. By the action of acids or of heat it is converted into starch, and therefore if a little sulphuric acid be added to it, the violet colour produced by the iodine (see next paragraph) is converted into a blue. Substances that contain a very large proportion of cellulose are not employed as human food, but such (as hay and straw) are much used in feeding cattle and horses; and when this is done, it is probable that the cellulose is converted into starch by the hydrochloric acid of the stomach. Cellulose is apt in old plants to part with a portion of its oxygen, and is then converted into a principle named lignine. This is known from cellulose by its solubility in caustic potassa water. As its hydrogen and oxygen are not united in the proportions that they are in water, it is not exactly a saccharine proximate principle. It exists in potato skins, the peel and core of fruit, the seed-coat or skin of nut kernels, &c., and it seems doubtful if it can afford food. The principle said to have been detected in mushrooms (and which perhaps also occurs in other cellular plants)—fungine, is probably a variety of lignine or of cellulose. Braconnot,[3] however, reports that it contains nitrogen. 2. *Starch.* In plants that have come nearly to maturity, starch is probably the proximate principle that, next to cellulose, is most abundant. It is also contained in large quantities in many ripened, indeed in most ripened

[1] The body of man, as will be more fully explained in section v., consists of carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorus, chlorine, iron, sodium, calcium, potassium, magnesium, and fluorine. As the body cannot *form* an element, of course the food must contain and consist of these elements.

[2] Johnston.

[3] *Anal. Chem.,* 79.

or matured ones. It is easily obtained from flour (or ground cereal grains); the tubers of potatoes; the stem of the sago-palm, &c., &c. If any vegetable structure that contains starch be washed with cold water upon a sieve, a milky fluid passes through, which, when set aside, deposits a white powder. This is starch. Starch is, when pure, without taste, colour, or smell. It does not dissolve in cold water, but does so very readily in hot; and, when this is the case, it forms, upon cooling, a gelatinous mass. When moistened with a solution of iodine, it strikes a blue colour. Its formula is 12 carbon, 10 hydrogen, and 10 oxygen; or 24 carbon, 20 hydrogen, and 20 oxygen. It therefore differs from the cellulose, from which it is probably derived, in containing one atom less (or the atoms that contain one atom less) of water. The *rationale* of the action of sulphuric acid, when it converts cellulose into starch, is that it abstracts from it this one atom of water. There are two subvarieties of starch, called *inuline* (obtained from the dahlia, and other roots), and *lichen* starch (which is procured from the lichen). They differ from common starch in their action upon iodine, in their relations to water, and in a very slight degree in the proportion in which their elements are arranged. But for all practical purposes these variations may be disregarded. 3. *Dextrine.* If starch be heated up to a temperature of 300°, or if diluted sulphuric acid be added to it, or indeed if it be boiled in ordinary water for some time, a proximate principle—*dextrine*—is obtained, which differs from starch in being soluble in cold water. This change of starch into dextrine is naturally brought about during the germination of those seeds that contain starch. In this case the change is brought about by the contact of a peculiar nitrogenous principle—diastase—soon to be noticed. This principle may be separated from barley that is being converted into malt in the malt-house, and if a little of this separated principle be added to any starch, it (the starch) is soon converted into dextrine—a substance that, although having the same chemical composition as starch, unlike that principle, is soluble in cold water. This conversion of starch into dextrine is brought about in nature by the action of diastase during the germination of those seeds that contain starch. The albuminous proximate principle of diastase will be afterwards noticed, and if a little of it be added to starch, the starch is speedily converted into dextrine. If sulphuric acid be added to dextrine, the dextrine is converted into another proximate principle of this group—sugar. The formula of dextrine is of course the same with that of starch. 4. *Gum.* Many vegetables secrete gum, of which proximate principle there are two varieties, which merely differ in the one, arabine, dissolving in cold, and the other, cerasine, requiring hot water for its solution. The chemical composition of gum is identical with that of dextrine and of starch, but gum differs from the latter in not giving the blue colour with iodine, and from the former in not readily giving up some of its oxygen and hydrogen to sulphuric acid, being thereby converted into sugar. 5. *Cane Sugar.* Many plants, as the sugar-cane, the maple, the beetroot, &c., contain another proximate saccharine principle, *cane sugar.* This is soluble in water, forming with it an oily compound—*syrup*—from which, however, the sugar gradually separates in crystals, which are commonly known as sugar-candy, and which sugar-candy has an extremely sweet taste. Its formula is 24 carbon, 18 oxygen, and 18 hydrogen. If diluted sulphuric acid, as before mentioned, be added to starch, first dextrine is obtained, and then cane sugar. And when cane sugar is itself heated with dilute sulphuric or other acids, it is blackened by it, and becomes converted into another form of sugar, next to be noticed. 6. *Grape Sugar.* This is found in the grape, apple, and many other fruits, and is produced from cane sugar by the action of acids and heat. In this latter mentioned manner it is extensively produced, when a solution of malt, &c. is fermented by the brewer or distiller. Grape sugar is neither so soluble in water nor so sweet as cane sugar. Its formula, too, is different, being 24 carbon, 22 hydrogen, and 22 oxygen; and it may be readily distinguished from cane sugar by not being blackened when boiled with diluted sulphuric acid. Other subvarieties of sugar may be omitted. One called pectine is contained in many fruits and roots, and contains an excess of oxygen. Combined with sugar, it forms a jelly. 7. *Alcohol.* Correctly speaking, this proximate principle does not belong to the purely saccharine group, for its atoms of hydrogen are in excess over those of oxygen. Neither does it, like all the above mentioned saccharine proximate principles, exist ready formed in plants, although by art,[1] when the plant has been some time dead, they can be converted into alcohol. In order to procure alcohol there must be a solution of grape sugar (or of cane sugar, dextrine, or starch, under those conditions in which these respective principles may become converted into grape sugar), a certain temperature, and the presence of some albuminous matter, as gluten (as in grapes), or yeast, as in beer-making, or the like. When these conditions occur, carbonic acid is given off, and alcohol is left in the water. The following is the change that occurs:—1 atom of grape sugar and 2 of water are composed of 24 carbon, 24 hydrogen, and 24 oxygen. If we subtract from this 4 atoms of carbonic acid, which contain 8 of carbon and 16 of oxygen, we have left 2 atoms of alcohol, which together contain 16 atoms of carbon, 24 of hydrogen, and 8 of oxygen. The formula of alcohol is therefore 8 of carbon, 12 of hydrogen, and 4 of oxygen. Obtained in this manner alcohol is always much diluted, constituting wine, beer, &c. To obtain it in a purer form it requires to be distilled and rectified.

B. *Saccharine proximate principles derived from Animals.*—1. *Milk Sugar.* If the milk of any mammiferous animal be taken, and the curd separated, as is done in ordinary cheese-making, and then the whey boiled so as to evaporate a considerable portion of the water, the remaining whey gradually deposits a number of crystals, which, on examination, are found to be a variety of sugar, to which the name of milk sugar is given. It is not so sweet to the taste as either cane or grape sugar, neither is it so soluble in water, and it is harder and grittier when chewed than they are. Its formula is 24 carbon, 19 hydrogen, and 19 oxygen. By the action of acids it is converted into grape sugar, and is then susceptible of the alcoholic fermentation. Milk sugar is never sold in this country except for scientific purposes; but in Switzerland it forms an article of commerce, and it is the source of the alcoholic drink of some nomadic tribes. In this last-mentioned case the lactic acid (see p. 758) is allowed to separate, the free lactic acid then converts this sugar into grape sugar, and the albuminous principle of the curd or cheese acts as a ferment. The physiological action of all the saccharine proximate principles is the same, and consists altogether, or mainly, in affording carbon, and this almost solely for the purpose of keeping up the animal heat, and not for the purpose of depositing fat. Man requires to keep up a temperature of about 100° Fahr., which is one much higher than that of the atmosphere that surrounds him. In order that he may do this his economy is able to take the carbon of his food, including, of course, the carbon of the saccharine principles that constitute his food, and combine it, just as wood, or coal, or coke are combined in a common fire, with oxygen (which oxygen man and animals take in at the lungs from the air). The result is, in this as in all ordinary cases of combustion, the formation of carbonic acid by the union of the carbon of the food and the oxygen of the air; and this carbonic acid, when the elements that composed it have served their purpose of heating the body, is cast out at the lungs. The amount of pure carbon necessary to be taken in as food by an ordinary-sized adult man for the purpose of burning in him is about eleven ounces a-day. But some of this may be derived, and in many cases is, from the oleaginous proximate principles now to be noticed.

C. *Oleaginous proximate principles derived from Vegetables.*—Plants usually, and, as far as regards those used as food, almost without an exception, contain a considerable quantity of oily matter. This is usually deposited around the seeds, as in the husks of cereal grains, or among the cellular tissue, as in turnips, potatoes, grass, &c. When fixed oily matter is present in considerable quantity in a vegetable, it may be generally separated by means of pressure, or, if that is not convenient, by being dissolved out by means of ether, and the ether afterwards evaporated. Volatile oils are readily obtained by distillation with water. The fatty matters that can be thus obtained from plants may, for all practical purposes, be ar-

[1] Alcohol is, however, sometimes produced in nature. Very ripe gooseberries, and probably grapes, and many other very ripe but ungathered fruits contain it.

ranged into three, viz.—1. *Elaine*, which is a liquid, and may be readily procured from the solid constituent of olive and other oils by freezing. The part, in such a case, that is left fluid is the elaine. There are two sub-kinds of it, one that is not acted upon by the air, and another that, when exposed to the air, absorbs oxygen, and undergoes other changes, the result of which is to convert it into a resin, or oxygenated oil. This latter is the drying oil of painters. The composition of the two kinds is identical, their formulæ being 94 carbon, 87 hydrogen, and 15 oxygen. 2. *Margarine.* This is the solid portion that is left when most vegetable oils are frozen. It is white, hard, and brittle, and melts at 118°. The composition is 74 carbon, 74 hydrogen, and 12 oxygen. 3. *Stearine.* This is very analogous to the preceding, and is obtained by freezing some vegetable oils (not, however, many), of which it constitutes the solid part. It differs from margarine in containing less oxygen, and in requiring a higher temperature (129°) to melt it. These oleaginous principles are usually mixed together in vegetables, and likewise contain small quantities of some essential oil peculiar to each plant, to which the odour and sapid taste are often owing.

D. *Oleaginous proximate principles obtained from animal articles of food.*—1. *Elaine.* This is the liquid part of almost all animal fats, and is quite identical with vegetable elaine. 2. *Margarine.* This is the solid part of the fat of man, the goose, cows, &c. It is the same as vegetable margarine. 3. *Stearine.* This is the solid part of the oily matter of cattle, sheep, pigs, and other animals, and in no respect differs from stearine obtained from vegetables. Animal oils, like vegetable oils, often contain a minute proportion of some oil peculiar to the animal, upon which their peculiar odour, sapid taste, &c., depend. These three oleaginous proximate principles of vegetables and animals are now, however, known to be compounds of elaic, margaric, and stearic acids with oxide of glycerine. For the properties and compounds of these substances see CHEMISTRY. The physiological action of the oleaginous proximate principles of plants and animals whose structures are used as food is, like those of the saccharine group, to furnish carbon, partly for the purpose of being consumed as food, and partly to furnish fat. Indeed, under ordinary circumstances, they only fulfil the latter indication. Nations the members of which, as Greenlanders, &c., have a small supply of saccharine proximate principles either to eat or to convert into alcohol, consume a large amount of animal fat. They have little or no vegetable fat; and something of the same kind has been observed to be the case with individuals in other nations who can obtain saccharine proximate principles, but who, from some reason or other, do not.

E. *Albuminous proximate principles obtained from vegetable articles of food.*—1. *Vegetable Albumen.* If the expressed juice of many plants, as of the potato, turnip, carrot, the seeds of the cereal grains, &c., be filtered, and the fluid that remains be exposed to a heat of 180° Fahr., a portion of it coagulates and falls down in flakes. This is albumen, and may be collected upon a filter. Albumen may be distinguished from other nitrogenous proximate principles by coagulating at a heat of about 180°, by drying into a hard white mass, by being soluble in alkalies, and by being precipitated from these alkaline solutions by all acids save the phosphoric and acetic. It is believed that albumen exists in plants in two states, one a soluble one, and another not so. Albumen essentially contains carbon, oxygen, hydrogen, and nitrogen. The exact proportions of these are perhaps not very accurately ascertained. The following is the result of an analysis by Jones:[1]—

Carbon, 54·74; hydrogen, 7·77; nitrogen, 15·85; oxygen, 21·64 = 100.

2. *Gluten.* If the flour of wheat or other cereal grain, or indeed of many other parts of several plants, be made into a dough with water, and the dough well washed, the saccharine and oleaginous matters, and also the albumen, are carried away by the water, and a stiff tenacious substance is left. This is gluten. It is, as the mode of obtaining it sufficiently indicates, insoluble in water, but it is partly so in alcohol. The portion that does so dissolve in alcohol is called glutin, and sometimes vegetable fibrine. The chemical composition of gluten is very analogous to that of albumen, out of which it is probably formed. Gluten does not coagulate at a heat of 180°, it dissolves in acetic acid, and may also be distinguished from other proximate albuminous principles by its great tenacity. 3. *Vegetable Caseine.* After boiling the sap of some plants, as of potatoes, pears, &c., and straining the liquid that remains from the albumen that is by the heat coagulated, if a little hydrochloric (or other acids) be added, a white powder gradually falls to the bottom. This is caseine. Its chemical composition probably differs but slightly from those of albumen and gluten, but it may be known by its coagulating in many acids. 4. *Theine.* If tea, coffee, or cocoa be boiled in water, and the solution treated with sugar-of-lead, this proximate principle, theine, which had been combined with tannic acid, is thrown down in brilliant long crystals of a silvery lustre. It is composed of carbon, oxygen, hydrogen, and nitrogen, but the latter is in greater proportion than in any other albuminous compound (it actually contains 29 per cent. of this element), and, as we shall afterwards see, this accounts for the nutritious effect of tea, &c., in individuals who consume little food of other descriptions. 5. *Diastase.* If pounded malt be infused in cold water, the solution considerably evaporated, and then alcohol added, a white powder falls down, to which the name of diastase is given. Diastase exists in all *germinating* seeds or tubers, and is probably during germination the last product obtained from the above-mentioned albuminous principle caseine. If a little of this diastase be applied to starch it has the remarkable property of converting it, first of all into (soluble) dextrine, and eventually into grape sugar. Diastase is an albuminous proximate principle, but its exact composition is not known, one reason for this being that it is very readily decomposed and separated into inorganic compounds, one of these being ammonia. The very important action that it has in ripening and maturing vegetable productions is ascertained, but in this place we have only to consider its action in fermentation. It is not known if diastase in itself furnishes nutriment or not.

F. *Albuminous proximate principles obtained from animal articles of food.*—*Animal Albumen.* This constitutes the white of the egg, or it may be readily obtained by heating the serum of the blood up to 180° (Fahr.), upon which it coagulates and falls down in flakes. It is also abundant in almost all animal tissues. It is probably exactly identical in all its properties with vegetable albumen. 2. *Fibrine.* If recently drawn blood be whisked with a birch wand, a white fibrous matter attaches itself to the twigs. This is fibrine. It may also be obtained by a little management from any muscular structure. It differs (besides in other respects) from albumen in coagulating at ordinary temperatures, and from gluten (to which principle it is very analogous) in coagulating at all. Its formula is carbon 52, oxygen 23, nitrogen 16, and hydrogen 7. It is probably formed in animals out of albumen. 3. *Gelatine.* This may be obtained by boiling bones, skin, cartilage, &c. in water, and putting the solution to cool. It is distinguished from the two former substances by dissolving readily in hot water, and by this solution forming a jelly-like mass when cold. It also combines with tannin and forms the impervious compound called leather (which contains also fibrine). Gelatine is probably formed out of fibrine, and in its chemical constituents is nearly identical with that compound, but it contains a little more oxygen. It is important to recollect that pectose, which is sometimes called vegetable gelatine, is not an albuminous compound at all. 5. *Kreatine.* Some years ago Chevreul announced the presence in butcher meat of a crystallizable principle to which he gave the name of kreatine. It is, however, almost certainly the product of decomposition, and in no degree nutritive. 6. *Osmazome.* Cooked animal meat has a very different smell and taste from the same when raw. If the former be treated with alcohol, an odorous and sapid extract is obtained, to which the name of osmazome has been given. If this be a proximate principle, it is almost certainly an albuminous one, but it is very doubtful if it is such. It is perhaps a compound of lactates with the salt employed in cooking, but it may be that part of it is a resin obtained by the deoxidation of some of the fat during the application of heat. 7. *Proteine*, and the ashes of vegetable and animal structures that are used as food. If the structures of vegetables and animals that are used as food be examined, they are found to consist of an aggregation of several of the above proximate prin-

[1] *Annalen der Chimie.*

ciples (or of slight modifications of them that are purposely omitted), of water, and of a small quantity of salts, or of the acids and bases that form salts. If any of the substances that we use as food be exposed to considerable heat, the water is first driven off, the four elements in the proximate principles just noticed enter into new combination (carburetted hydrogen, ammonia, &c. &c.), and pass off into the air, but a small quantity of ash is left behind. In plants this ash is found to consist of sodium, potassium, chlorine, phosphorus, sulphur, calcium, magnesium, iron, silicon. In animals the constituents of the ash are the same, with the exception that animals contain no silicon. In the undestroyed structures of vegetables and animals these constituents of the ash probably exist as chlorides, phosphates, and sulphates of soda, potassa, &c. (or chlorides, phosphurets, and sulphurets of sodium and potassium), iron, &c. It has been maintained that the albuminous proximate principles are in reality compounds of a peculiar substance, to which the name of *proteine* has been given, and that the difference of the albuminous compounds essentially consists in their being respectively combined with varying portions of these constituents of the ash. This opinion is perhaps not supported by sufficient evidence, but the elements that form the ash may be considered as in some way or other united during life with the albuminous proximate principles of vegetables and animals.

G. *Acids found in the recently dead structures of plants and animals that serve for food.*—a. *Acids derived from vegetables.*—1. *Acetic acid.* This acid and the following (the lactic) resemble the saccharine proximate principles in being composed of carbon, hydrogen, and oxygen, and in the hydrogen and oxygen being in the same proportions as they exist in water. But they differ in this that they have an acid reaction, reddening litmus paper, and forming neutral salts with alkaline bases. Acetic acid as formed during the germination of seeds, is a product, at least often, of incipient putrefaction in many plants, particularly in those that had contained much sugar, but it probably also is contained in many living juices. Acetic acid (undiluted) consists of 4 carbon, and 3 respectively of hydrogen and oxygen. One of its chemical characteristics is that its solution gives a white precipitate (acetate of silver) with lunar caustic, and that this pricipitate is little soluble in water. Acetic acid is also obtained abundantly from the fermentation of wéak alcohol and the destructive distillation of wood. 2. *Lactic acid.* If chopped cabbage, flour, grains, or many other vegetable substances, be allowed to ferment, the starch or sugar is decomposed, and lactic acid is formed. The composition of it is carbon 6, hydrogen 6, and oxygen 6. It is also formed in animal structures that are beginning to undergo putrefaction. It perhaps never occurs in a living plant or animal. It appears, however, to be certainly an aliment. 3. *Tartaric acid.* This and the following consist of carbon, hydrogen, and oxygen, but they have the last-mentioned element in excess. They have acid reactions, but may be regarded otherwise as corresponding with the oleaginous principles of food. Tartaric acid exists in the juice of the grape, tamarind, and other fruits. In combination with potassa (argol), it is deposited in wine-casks and bottles. Its composition is carbon 4, hydrogen 2, and oxygen 5. 4. *Malic acid.* This acid exists in large quantities in apples, pears, and other fruits, particularly before they are ripe, or in those varieties of them that never become very ripe or sweet. Its composition is carbon 4, hydrogen 2, and oxygen 3. b. *Acids derived from animals.*—1. *Lactic acid.* If milk be allowed to stand for a while, it becomes sour. This is owing to its sugar, or a part of its sugar, having become converted into lactic acid, a substance identical with that noticed above, as being formed by the decomposition of cabbage, &c. It is also formed in flesh undergoing incipient putrefaction. 2. *Butyric acid.* This acid exists in butter, a substance that contains likewise two other acids, the consideration of which may be here omitted. 3. *Inosinic acid.* This acid perhaps exists in flesh just beginning to putrefy.

H. *Composition and physiological action of the different parts of animals and vegetables usually employed as food, and which contain two or more proximate principles.*—a. *Vegetable structures.* The various nutritive principles are generally so much combined in vegetables that a very few lines may suffice for this section. The stem of young edible plants is usually composed of cellulose, oil, some sugar and starch, and a small quantity of albuminous matter. The seed of the cereals, besides starch, a little sugar, and gum, contains a large amount of albuminous matter, surrounded by a husk that is very rich in oil. Esculent roots and tubers generally contain an admixture of albuminous matter, saccharine (usually starch), and oleaginous, the two last usually preponderating. Ripe fruits, besides albumen and oil (this in general very sparingly), contain sugar in considerable amount, and usually one or more acids. Unripe fruits consist almost entirely of cellulose and acids. All of these have also a large quantity of water mixed up with their structures. b. *Animal structures.*—1. *Bone.* This substance consists of about 33 per cent. of albumen and gelatine, principally the latter, and about 67 of phosphate of lime and other commonly-termed inorganic matters. The long bones also contain marrow, a substance which is a mixture of elaine and stearine. The bones of young animals contain a much larger proportion of the gelatine than those of old ones of the same species. 2. *Cartilage.* This consists almost entirely of gelatine and albumen, and is analogous to bone that has been deprived of its inorganic matter. 3. *Cellular Tissue.* This consists of cells that are composed of an albuminous principle, probably gelatine, and which inclose elaine and margarine. When the cells are very much filled with the fatty matter, the compound is named adipose tissue, or commonly fat, and a variety of it suet. 4. *Muscle.* The flesh of animals consists of muscle proper or lean, and also, in all or nearly all animals relished as food, of fat, which is deposited in the cellular tissue surrounding the fibres, and also that surrounding the entire muscles, which then often becomes adipose tissue. Some albumen, too, derived from the blood is contained amongst it, and of course various saline matters. As before mentioned, the kreatine found in dead meat is probably the first stage of decomposition, and the osmazome present in cooked meat developed by that process. Muscle contains about 74 or more per cent. of water. 5. *Glands and Viscera.* The tongue, the kidney, the sweetbread, and other internal organs, are used for food. They generally contain a good deal of albumen and fibrine. Sweetbread contains 6 per cent. of gelatine, liver has a peculiar brown oil, and the kidneys certainly often appear to retain urea. 6. *Nervous Matter.* Nervous matter contains albumen, various fatty matters, a peculiar acid that contains about 2 per cent. of nitrogen, various saline ingredients, and about 80 per cent. of water. Nervous matter is very little employed as food, being only occasionally used as a garnish. 7. *Blood.* Blood constitutes so great a proportion of the structure of animals, that some is almost invariably retained in the muscular structure. But blood is only used by itself as an article of food in the form of black puddings, which consist essentially of cooked hog's blood. Blood in composition and in nutritive quality is analogous to flesh.

II. *The varieties of animals and vegetables used as food in this country, the different elementary products obtained from them, and their various composition.*

A. *The varieties of Alimentary Vegetables.*

a. *Cereal Grains.*—1. *Wheat* (*Triticum*). The grain of wheat has for a very long time constituted an important article of food, and in England has for about three centuries been the staple grain. The kind usually cultivated is the *Triticum sativum.* A bushel of it should weigh, if very good, about 64 lb. Wheat in the form of flour is sometimes manufactured as macaroni and vermicelli; but its almost universal use is as bread. (See BAKING). The following is the composition of first-class wheaten flour:—Water, 14·0; albuminous compounds, 14·6; oil, 1·2; saccharine compounds, 66·9: cellulose, 1·7; ash, 1·6. The greater part of the ash is made up of phosphorus, potassium, and magnesium. The bran contains much less saccharine matter, but absolutely more oil and more albuminous matter; and "seconds" in this respect stand intermediate between fine flour and bran. The cheaper price of seconds and bran, therefore, appears to be somewhat arbitrary and improper, and brown bread is probably more economical than that made from fine flour. The objection to it is probably that bran does not leaven particularly well. 2. *Oats* (*Avena sativa*). In Scotland, the climate and soil of which seem peculiarly adapted to its cultivation, this cereal has long constituted the staple article of diet. This is also the case in the high-lying land in the West Riding of Yorkshire and the adjacent parts of Lancashire. A bushel of good oats weighs about 45 lbs. Oats are made into flour or meal, and before being submitted to the mill they are always kiln-dried, to facilitate the separation of the husk. The proportion of husk is

perhaps about a quarter per cent. When the husk is separated, but before the grain is ground, the seeds receive the name of groats. When ground the dust constitutes oatmeal, and it is found in practice that oats afford about half their original weight of meal, the loss being the water expelled by the kiln-drying, the husk, and the chaff. The following is Norton's analysis (the arrangement being altered) of oats that had been dried to 212°. Perhaps in this drying the loss of water would be about 20 per cent. Albuminous compounds, 19·91; saccharine do., 68·68; oleaginous do., 7·33; husk, 2·28; ash, 2·60. The proportion of ash, principally phosphates and sulphates of lime, potassa, and magnesia, is sometimes in much larger quantity. Oatmeal, therefore, contains considerably more nutritious matter than the same weight of wheat flour. The husks consist mainly of cellulose, and are almost never used as human food. 3. *Rye* (*Secale cereale*) has been cultivated from time immemorial, and was for long much used for breadmaking in this country, as it still is (constituting the staple) in Russia, many parts of Germany, &c. A bushel of rye weighs about 54 lb. Rye grain is very coarsely powdered, and the mixture of flour and bran made into fermented bread, which is distinguished from other bread by its black colour. The following is an analysis of rye flour, the water having been previously expelled. Albuminous compounds, 10·5; saccharine do., 78·0; oil, 3·5; salts, 6·0, principally phosphates of potassa, soda, and magnesia; loss, 2·0=100·0. These three cereal grains constitute the basis of the food of the modern European nations. In order that wheat may produce a good crop, it requires land rich in alumina, and also considerable summer heat; while rye thrives best on sandy soil. The oat does best with a dampish and somewhat cold climate, and seems to almost prefer a thin soil lying over primitive and metamorphic rocks. 4. *Barley* (*Hordeum distichon*). Barley is occasionally made into bread; and it is also used, when deprived of its husk, for making soup. But by far the most important use of barley is that it may be converted into malt (*i. e.* that its starch may be converted into sugar), for the purposes of brewing and distillation. The reason it is thus selected is, that of all grains, if put under the conditions favourable to germination, its diastase soonest converts the starch into sugar. A common weight of a bushel of good barley is 56 lb. It contains about 68 per cent. of starch, upon which its value to the maltster or distiller mainly depends. 5. *Rice* (*Oryza sativa*) supplies in the Eastern world the place occupied in the Western by wheat, oats, and rye, and is also pretty extensively used on a small scale in this country. The following analysis of rice is abstracted from Payen;—Albuminous principles, 7·5; saccharine do., 87·3; oil, 0·8; salts, 0·9; woody tissue (cellulose), 3·4. Thus, save in saccharine proximate principles, rice is far less nutritious than any of the preceding. 7. *Indian corn* (*Zea mais*) is the staple of North America, Mexico, &c., and has been, in times of scarcity of our own cereals, beneficially imported into this country. It is also sometimes, but precariously, cultivated in England. According to Payen, 14 or 15 per cent. of water having been previously expelled, the grain contains more than 12 per cent. of albuminous matters, nearly 72 of saccharine, and the immense proportion of 9 of oleaginous. It is, therefore, extremely nutritive.

b. *Viniferous Vegetables.*—1. *Grape* (*Vitis vitifera*). The grape vine is one of the oldest of our cultivated plants, the main object of its culture having been, as now, to obtain from its juice a wine, which is the staple drink[1] of many millions of men. Like the wheat plant, its native habitat is unknown, and if neglected by man it degenerates. The limits to the culture of the vine in Europe are (Boussingault) where the mean temperature is from 50° to 52°, and where the mean heat of the summer is from 65° to 67°. Ripe grape juice, when expressed, is found to contain grape sugar, gluten and albumen, tartaric acid and potassa, a volatile oil, tannin, colouring matter, and water. Of dried grapes or raisins there are two kinds, the smaller or Corinthian currants, and the larger, of which there are many varieties.

c. *Sugar-yielding Vegetables.*—1. *Sugar-Cane* (*Saccharum officinale*). Its ripe juice consists of sugar, gum, acetic acid, malic acid, potassa, &c. This is boiled with lime, and then evaporated, the raw or muscovado sugar being obtained. The impurities are got rid of by means of refining, and crystallized sugar is the result. A portion of the sugar, however, will not crystallize, and constitutes the tenacious fluid called molasses or treacle. Cane sugar is now enormously consumed as an article of food. Although the dietetical action of sugar is unquestionably mainly to supply carbon for the purpose of respiration, it would also certainly seem to be able to afford fat. During the time of taking the crop in Jamaica, and when the labour is severe, the work-people use it liberally, and "every negro on the plantations, and every animal, even the dogs, grow fat."

a. Subsection of Sugar-yielding Vegetables. Fruits.—1. *Apple* (*Pyrus Malus*). A great many varieties of apples are cultivated, some of which, perhaps, differ a little in the relative proportion of their constituents. Their average composition is probably about 85 or 86 per cent. of water, 10 of saccharine (a portion of this, however, gum), rather more than one of malic acid, and a small quantity (perhaps not yet ascertained) of albuminous principles. They likewise contain a volatile matter, salts, and some tannin, as is indicated by the black colour they strike if cut with a steel knife. In many parts of France and the States of America, apples constitute an important article of food, but unless the amount of albuminous matter is greater than is known, they can only afford carbon to the system. 2. *Pears, &c.* (*Pyrus communis*). The pear does not materially differ in chemical constitution from the apple. The varieties of smell and taste probably are dependent upon a little peculiar volatile oil. A jargonelle yields one-fifth of albuminous matter. Plums, cherries, oranges, &c., consist mainly of water, with a small portion of saccharine, a still less of albuminous principles, malic and other acids, and various essential oils upon which their flavours and colours depend. 3. *Gooseberries, Currants, &c.* (*Ribes*). All these are tolerably nutritious, containing nearly seven per cent. of saccharine proximate principles, and almost one of albuminous.

d. *Products obtained by art from Sugar-yielding Vegetables.* With the exception of cane sugar, the products artificially obtained from the preceding sugar-yielding plants are in this country of far more dietetical consequence than the original structures of the vegetables themselves. The theory of the preparation of their products will be found in Section III. In this place their chemical composition, their physiological action, and their more important varieties, are described. 1. *Wine.* This beverage consists of grape-juice, the sugar of which has, by the action of its albumen, been made to ferment, to evolve carbonic acid, and to leave behind alcohol. As grape-juice essentially contains tartaric acid, so does wine essentially contain it, and this possession of tartaric acid is in fact the distinguishing mark of wine from other fermented drinks. Wine also contains a volatile oil, which seems to vary much in grapes grown in different climates and on different soils, and this oil is technically called its *bouquet.* Wine also contains a colouring matter, often tannin, free acids, &c. *Wines may be arranged into three classes.*—*a.* Thoroughly fermented wines, in which all the sugar, or nearly all of it, is converted into alcohol and carbonic acid, and the latter product allowed to escape into the air. This class includes port, sherry, burgundy (still), claret, hock (which, however, contains an excess of tartaric or other acid), madeira, and the like. *b.* Wines not thoroughly fermented, and in which a considerable portion of the sugar remains as undecomposed sugar; as tent, tokay, frontignac, Candian wine, &c. *c.* Wines thoroughly fermented, but in which some of the carbonic acid is not allowed to escape into the air, but retained in the liquid, as in champagne and sparkling moselle. The proportion of alcohol in different kinds of wine is variable both in the different kinds of wine and in different years. Port usually contains about 25 per cent., claret about 15, and hock and champagne about 12 per cent. In France, however (where the chemical changes that take place in wine-making are thoroughly understood), if the juice of the grape contain too little sugar, beetroot sugar is added, and thus the average strength of French wine is kept up. The great dietetical use of wine, in a mere animal point of view, is to supply carbon for the purpose of preserving the animal heat, and it will be observed that alcoholic compounds are more permanent than most other saccharine or oleaginous matters, and less bulky than these. The action of wine upon the nervous system is also an important one, but one that need not here be entered into. An average yield of wine per acre in France is 170·9 gallons. 2. *Cider and Perry.* These are produced by converting the sugar of apple and pear juice into alcohol. This is effected by bruising them, and then mixing up in one pulp the saccharine and albuminous proximate principles. See CIDER. They both, however, differ from wine in containing malic instead of tartaric acid. Besides alcohol, malic acid, and water, cider and perry contain volatile oil, colouring matter, &c. The physiological action of these beverages is probably identical with that of wine, but malic acid fermented drinks are not so much relished as tartaric acid ones. Cider and perry contain from 8 to 9 per cent. of alcohol. 3. *Beer, Ale, and Porter.* These consist of solutions of the sugar of malt, which has been converted by fermentation into alcohol. They also contain the soluble principles of malt, and for long have been flavoured

[1] It is not perhaps sufficiently borne in mind that all articles of food approach more or less to the liquid form, and in this respect only differ from one another in the proportion of water which they contain. And this difference is by no means so great as is generally supposed. Butcher meat may be put down generally as containing about 75 per cent. of water, and beer 95 per cent., turnips nearly 90, &c. &c.

with infusion of hops. When coloured black or dark brown by means of charred malt, porter is obtained; when not so coloured, the strong kind constitutes ale, and the weaker beer. All malt fermented liquors differ from wine and cider in containing neither tartaric nor malic acids. London porter contains on an average about 4 per cent. of alcohol; stout, nearly 7; ale, perhaps nearly the same; and beer, 2 more or less. Beer that cannot be distinguished from the above is made by employing common sugar instead of sugar of malt. The physiological action of malt liquor is identical with that of wine and cider. (See BREWING.) 4. *British Wines*. These are the fermented juices of native fruits, to which, as they seldom contain enough sugar to afford the requisite amount of alcohol, sugar is generally artificially added. Most of our fruits contain malic acid, and therefore domestic wines resemble cider; but if argol be added during the fermentation, they then become analogous to grape wine. The demand for them not being, at least openly (for a great deal of supposed continental wine is of home origin), very great, they are sold at a high profit, but they might be produced nearly as cheap as cider. Their physiological action is the same as that of other fermented drinks. 5. *Alcohol and spirituous drinks*. Alcohol evaporates at 173°, while the boiling point of water is 212°. Hence the alcohol can be separated from any of the wines, ciders, or malt liquors, by a little skilful application of heat, and then condensed in proper vessels. This separated alcohol can also be freed from essential oils and other impurities; and when so freed and mixed with one-half of water, it constitutes proof-spirit, which has a specific gravity of ·920. Proof-spirit, however, is not used dietetically, but several varieties of it either naturally or artificially flavoured are extensively consumed. The most important of these are—a. *Brandy*. When wine is distilled, there comes out along with the alcohol a quantity of water, and of the flavouring matter of the wine. This is brandy. It contains 53 per cent. of alcohol. A fictitious brandy is made from cider, malt, and from fermented potatoes, the latter constituting British brandy. b. *Rum and Whisky*. These are the distilled spirits of the fermented juice of the sugar cane and of malt (or *wash* as the distiller calls it). Both these are the strength of 11 overproof, sometimes (as always in the case of newly-imported rum) much more; and the physiological action of all of them is to supply carbon to the system. They perhaps contain the carbon in far too concentrated a form for actual use until diluted. They are also powerful stimulants upon the nervous system, this action being probably the result of their carbon-supplying properties. c. *Liqueurs*. Among these may be noticed—gin, which is spirit flavoured with sugar, and in the better kinds juniper berries, but in the inferior oil of turpentine; curaçoa, which is a solution in alcohol of sugar and peach-stones, or other analogous stone fruits, which undergo decomposition with some of the water present, and form a little prussic acid; crême d'absynthe, which is essentially a solution of wormwood in alcohol, sugar, and water. The physiological action of liqueurs is essentially the same as that of spirits. d. *Vinegar*. This is a diluted solution of acetic acid, generally obtained by the farther fermentation of alcohol, but sometimes now by the destructive distillation of wood. Vinegar, properly speaking, is soured wine or ale (alegar), but in practice a solution of sugar is employed to prepare commercial vinegar. This first becomes a solution of alcohol, and then, by obtaining more oxygen, a solution of vinegar. At sea, and in many parts of the continent, vinegar (or sour krout) is found very useful as affording a supply of carbon. It has probably also another action; for a certain supply of vegetable acids seems essential for the long-continued preservation of health. (This subject will be noticed in Section V.) In this country it is chiefly valued for its antiseptic properties.

e. *Leguminous Plants*. The leguminous plants used as food in this country agree in their seeds being when ripe exceedingly nutritious, and also in affording an agreeable although less nutritive food when immature. 1. *Bean* (*Vicia faba*). The ripened seed of the bean is scarcely ever now avowedly used as human food, although it is a very common practice among millers to mix bean-flour with that of wheat. Bean-meal is extremely nutritious, containing 22 per cent. of albuminous proximate principles, 45 of saccharine, and about 3 of oleaginous. A bushel of good beans weighs 65 lb. Immature beans contain much more water and less albuminous matter. 2. *Pea* (*Pisum sativum*). Ripe peas ground into meal, and baked with water or milk, were formerly a very common article of food in Scotland, but peas bread or bannocks are now almost entirely confined to Selkirkshire and a few other localities. Ripe peas are extremely nutritious, containing 20 per cent. of albuminous proximate principles, 55 of saccharine ones, and 2 of oleaginous. They are much used for soups, and very extensively and very beneficially in the royal navy along with fat pork. In this case, contrary to the vulgar opinion, the peas afford the nitrogenous (or what is incorrectly called *the* nutritious matter, *par excellence*), and the flesh the carboniferous matter. Beans and peas, perhaps, contain somewhat less phosphates than the cereal grains. 3. *French Beans* (*Phaseolus vulgaris*). This, the kidney bean, and another variety, the scarlet, are much cultivated abroad for their ripe seeds, which are very nutritious, but in this country their pods before they are ripe are eaten. They probably contain a very small quantity of *salts*.

f. *Brassicacious Vegetables*. All the edible members of the cabbage family are wholesome articles of diet, and nutritious, considering the very large proportion of watery fluid which they contain; inasmuch as they contain an admixture of saccharine, oleaginous, and albuminous proximate principles. They generally contain a large proportion of sulphur, and, when boiled, some of this usually combines with some hydrogen, sulphuretted hydrogen being formed, and thus give rise to the disagreeable smell of water in which cabbage, &c. has been boiled. 1. *Cabbage* (*Brassica*, various kinds of). Under this head may be comprehended the kinds used for their leaves, kail, hearting cabbage, savoys, and Brussels sprouts, all of which are merely modifications of the same original stock. They contain about 92 per cent. of water, some albuminous principles, some saccharine, and a considerable quantity of oleaginous. Their ash is usually great, and contains a good deal of sulphur, chlorine, phosphorus, soda, potassa, and lime. If cabbage be sliced and pressed, its saccharine principles become converted into lactic acid, and sour krout is produced. It is a nutritious, and, as will appear in Section V., a wholesome winter dish, but it is little used in this country. *Cauliflower*. The flower of this species of cabbage is the part used. It is remarkable for containing an immense amount of albuminous matter. 2. *Turnips* (*Brassica rapa*). A turnip contains about 89 per cent. of water, 7 of saccharine principles, less than 1 of albuminous, and about $\frac{1}{5}$th of oil. Its ash is rich in phosphorus. Sea-kale and other vegetables of a somewhat analogous nature are omitted, they being only used on a small scale, and there being no accurate analyses of them.

g. *Root Crops*.—1. *Potato* (*Solanum tuberosum*). It is only in popular language that the potato can be called a root. It is a tubercle or tuber attached to the root and subterranean stem. A well-grown potato contains about 75 per cent. of water, nearly 20 of saccharine compounds, about $1\frac{1}{2}$ of albuminous, and a small quantity of oleaginous. Its ash, which constitutes on an average at least 1 per cent., contains a very large quantity of potassa, and a considerable amount of phosphorus and sulphur. Potatoes have also been stated to contain citric acid. Potatoes are a nutritious article of food, and capable alone of maintaining life; but their saccharine principles are so much in excess that they ought to be eaten along with articles of food abounding in albuminous and oleaginous principles. It may be here mentioned that pigs fed upon potatoes only become fat, and acquire more fat than the oil of the potatoes can be expected to afford. This is a strong reason for admitting that saccharine proximate principles can be deoxidated in the animal economy, and deposited as oleaginous. 2. *Beet* (*Beta vulgaris*). The white beet, or mangold-wurzel, is seldom grown for human food, and is not palatable; but the red kind is a common article of diet. This contains about 2 per cent. of albuminous compounds; the amount of oily matter has not yet been ascertained, but the saccharine proximate principles amount to the very large proportion of 15 per cent. For the last-mentioned cause beet (a white variety) is much grown in France and Belgium, for the purpose of extracting sugar from it. Did the excise regulations permit it, it is calculated that sugar might be produced from beet by the farmer of this country, and sold with a profit at $2\frac{1}{2}$d. a pound. If desired, too, all the fermented and distilled drinks of this country might be made from beet sugar in place of barley and other corn. The ash of beet consists mainly of potassa, but it also has something like 10 per cent. of silica. It also contains a considerable portion of other alkalies and alkaline earths, and very little acid. 3. *Carrot* (*Daucus carota*). The root of the carrot contains 80 per cent. of water, about 18 of saccharine proximate principles, 1 of albuminous, and a little oil. It has also a volatile oil, and some malic acid. Its ash is considerable, and has much potassa and common salt. 4. *Parsnip* (*Pastinaca sativa*). This is a very nutritious root, as it contains 18 per cent. of saccharine principles, and more than 2 of albuminous. The amount of its oleaginous contents and of its ash do not seem to have been ascertained. Owing to its large quantity of sugar it is sometimes fermented; and from this liquid a spirit is also distilled. 5. *Girasole*, vulgarly *Jerusalem Artichoke* (*Helianthus tuberosus*). The tubers contain 77 per cent. of water, 18 of saccharine proximate principles, about 1 of albuminous, and some fat. It has also some citric acid. The ash is pretty considerable. Skirret, scorzonera, and some other roots now little used as food, are omitted. h. *Alliaceous vegetables*. These plants are extensively employed as food in many continental states, but are in this country principally used as flavouring agents. They contain albuminous and saccharine matter (probably in very considerable quantity), and a peculiar volatile oil to which they owe their flavour and pungency. This oil appears to relieve the oppression of very hot weather. They contain citric acid, and their ash is rich in

sulphur and phosphorus. The most important of them are the onion and the leek. In this country garlic, rocambole, eschallots, and chives, are little grown. i. *Asparaginous vegetables.* Asparagus, artichoke, and spinach are nearly entirely composed of water, but they have some saccharine principles, and also peculiar ones to which they owe their characteristic flavour. They probably contain acids. k. *Salad vegetables.* Lettuce, celery, endive, &c., perhaps contain a larger proportion of nutrient matter than is generally thought, as they constitute an important article of diet in most southern continental countries. They probably are mainly useful in affording carbon, and thus allowing the eater to dispense with an equivalent of fermented drink. But there does not appear to be any recent analysis of them. l. *Nuts.* Nuts are little employed as an article of diet in this country, but in many continental states they form staple articles of food, and are very nutritious. The sweet acorns, the seeds of the ilex, are chiefly those eaten, and contain 47 per cent. of saccharine proximate principles, 15 of albuminous, and 3 of oleaginous. The nuts chiefly eaten in this country are the hazel, the walnut, and the chestnut. m. *Oil-producing vegetables.*—1. *Olive tree* (*Olea europea*). The expressed oil of the olive is the only vegetable oil that is dietetically used in an isolated form in this country. The oil is imported from the south of France and Italy, and also, but of inferior quality, from Spain. It consists of oleine and margarine, the former being most abundant. Its alimentary action is to supply carbon. On the Continent it is extensively used with bread and a great many dishes, but in this country its use is confined for the most part to salads. In many parts of Italy and Greece ripe olives are salted, and form a staple food. Unripe olives pickled in an aromatic solution of salt are imported as a luxury to this country. n. *Beverage vegetables.*—1. *Tea* (*Thea viridis* and *Thea Bohea*). The prevalent opinion is that black tea is the produce of *T. Bohea*, and green of the *T. viridis*, and that the different varieties of each sort depend upon modes of preparation. Notwithstanding the immense consumption of infusion of tea, and the very important place that it has taken among the dietetics of this country, our knowledge of its chemical constitution, and consequently of its physiological action, is by no means definite. Tea certainly would appear to contain at least a third of an astringent principle, about 6 per cent. of saccharine proximate principles in the form of gum, 2 or 2½ of volatile matter, upon which its fragrance &c. depend, and 6 of albuminous matter, including about a half per cent. of the peculiar principle called *theine*. From 45 to 50 per cent. are cellulose or lignin. Even from this very imperfect analysis it will be apparent that an infusion of tea is a nutritious agent, affording to the system saccharine and albuminous, and perhaps oleaginous proximate principles. Daily experience proves this; for many people who lead a sedentary life, *i. e.* who require not very rapid supplies of food, particularly of nitrogen and carbon, keep up their flesh and strength upon a diet of which tea is the principal or a principal part. Indeed a pint of tea of ordinary strength will contain nearly 1 per cent. of albuminous and saccharine compounds, which is not much less than weak soup has. But the principle *theine* has perhaps some nutritive action with which we are not yet familiar; and this probability is increased when we consider that both coffee and chocolate contain it. Liebig's conjecture is that it serves to form bile; but this hypothesis is not likely to find much favour with those English physiologists who maintain that bile is an excretion. The action of tea upon the nervous system will be noticed in Section V. Green tea differs from black in containing more volatile oil and more tannin, although this latter is denied. The different commercial kinds of black and green teas differ from one another in their mode of preparation, and in the consequent amount of volatile matter &c. they possess. The following are the most important of them. a. *Varieties of Black Tea.* a. *Bohea.* This, and particularly the kind called Canton bohea, is the refuse and large and coarse leaves of the other black kinds, and is often employed to adulterate other sorts. b. *Congou* is the full-developed leaf, and is the kind generally used in this country. c. *Souchong* is another full-developed black-tea leaf, and is distinguished from the previous by the greener colour of its infusion. d. *Pekoe* is prepared from the undeveloped or unexpanded leaf-bud of the black tea. It is considered the best kind, but is difficult to procure unmixed. b. *Varieties of Green Teas.*—a. *Twankay* is a common kind not much used. It consists of the expanded leaf. b. *Hyson* consists of the expanded leaf, but it is said to be of the second or third crop. It is the green tea usually drank in this country. c. *Gunpowder* consists of the unopened buds of the spring crop of the green-tea plant, and, like the pekoe, it is the best of its class. According to Mr Fortune the green tea is a leaf dyed in the process of drying by a mixture of indigo, turmeric, and gypsum. 2. *Coffee* (*Coffea arabica*)—the berries of the coffee plant with the husk removed. The following analysis of coffee is by Payen:—Cellulose, 34; water, 12; fat, 13; dextrine and other saccharine principles, 15; caseine, legumine, 10; nitrogenous substance, 3; caffeine (theine), 8; oil, 3; ash, 6; other matters, 3. According to this analysis coffee is an extremely nutritious substance. The roasting process, preparatory to its infusion, has no effect upon its nutritive properties, but merely communicates the characteristic flavour and smell. Of the several kinds, the Mocha coffee is the most esteemed. 3. *Chicory* (*Chicorium Intybus*). The roasted root of this plant when ground is either mixed with coffee or used alone. We have no recent analysis of it, but we know that it contains a good deal of saccharine principles, and a bitter extractive matter upon which its flavour seems to depend. Experience also teaches that it is perfectly wholesome, and to many people it forms a very palatable beverage. (See CHICORY.) 4. *Chocolate* (*Theobroma Cacao*). The kernels of the seeds of this plant contain more than 50 per cent. of oleaginous matter, nearly 17 of albuminous, and 18 of saccharine principles. It also possesses a principle called *theobromine*, analogous to theine. Chocolate is consequently one of the most nutritious articles of food which we possess; but its large quantity of oil makes it indigestible to many persons. It is now advantageously substituted in the navy to supply carbon, in place of some of the large quantity of rum formerly allowed. There are several modes of preparing the seeds. The roasted and ground kernels, made into a paste with vanilla, &c., and dried in mould, constitute chocolate proper. In order to diffuse it among boiling water it requires the somewhat tedious process of *milling*. A patent preparation (there are two or three varieties of it), Fry's chocolate, can be dissolved in water at once. The kernels of the roasted seeds constitute nib cocoa of the shops. The entire roasted seeds of both kernels and their husks ground down, make cocoa.

B. *The varieties of Animals used as Human Aliment.*

a. *Quadrupeds.* The various proximate principles that enter into the several structures of the quadrupeds used as human food are enumerated at p. 758. Herbivorous quadrupeds may almost always be eaten without danger. Sometimes, however, articles of food derived from quadrupeds do become poisonous, or at any rate injurious. The following have occasionally been noticed to do so. a. *Bacon*, and other cured or salted meat. There are several instances on record of bacon having become somewhat poisonous, although it has never perhaps destroyed life. It would appear that decomposition ensues, and that kreatine or some analogous compound combines with the salt or with the nitre used in the preserving, and that a deleterious compound is thereby produced. Such an accident, however, is extremely rare. b. *Sausage poison.* Sausages, at least in Germany, have pretty often acquired poisonous properties, and have occasionally destroyed life. This has generally occurred in long-kept sausages, and usually in the spring season. The decomposing sausages become acid and soft, and acquire a nauseous taste and smell. When, however, they begin to emit sulphuretted hydrogen their poisonous property is lost, but until then they are stated to be very deleterious. Of the nature of this sausage poison nothing is known. c. *Cheese.* Cheese has occasionally in Germany, and perhaps also in Cheshire, acquired poisonous properties, owing probably to some modification of an acetous fermentation. These very rare, and sometimes perhaps not very well-founded, cases of poisoning prove with what impunity in general food derived from quadrupeds may be used. 1. *The Ox* (*Bos taurus*). The flesh of the mature ox, or beef, constitutes in this country by far the greatest proportion of animal food that is eaten. That of the ox proper is most esteemed, next that of a heifer that has never been a milch cow, next that of a milch cow, and lastly that of a bull; it may be, however, that part of the dislike felt to the beef of cows and bulls is attributable to these animals not generally being slaughtered until they become so old that the cartilaginous matter dispersed among the muscles is tending to become osseous, and that other earthy deposits are being formed, the result of which is that the meat becomes ill-flavoured and tough. Occasionally some of the small breeds, as the Shetlands, are kept on grass for five years or longer, but by far the greater proportion of oxen are now slaughtered when they are in their third year, and some, as most shorthorns, before they are two years old. In this latter case, and indeed practically in almost all cases, they are now fattened more or less upon turnips, often with the addition of a little oil-cake. And it is quite certain that oxen put up to fatten in hammels in October, and slaughtered in a few months, *i. e.* entirely fattened without grass, afford as good beef as those altogether or entirely (as in the old way) fattened upon grass; and this is exactly in accordance with what our knowledge of the proximate principles of the food of oxen would teach us. The beef of the different breeds varies a little. That of the Shetland is perhaps the most compact, or finest grained as it is called. Next to the Shetland beef, that of the West Highland breed, and of the Welsh (the latter, however, rarely well enough fattened), is probably best; next that of the Galloways, Angus, and those of the Devon breed; and lastly the Herefords and shorthorns. But the last, or shorthorns, will always, in arable districts, form the preponder-

ating breed, from the readiness with which they become maturely fat at an early age upon turnips. Every hundred pounds of a fat ox give of butcher meat (including bones) 57·7 per cent.; tallow, 8·0 per cent.; hide, 5·5 per cent.; entrails and offal, 28·8 per cent. Some of the larger breeds grow to an immense size, attaining a weight of a hundred stones and more; but the beef of such is not in such estimation as that of the smaller kinds. Shetland oxen perhaps do not average twenty stones. The flesh of young bovine animals, which is known as *veal*, differs from beef in containing less fibrine, and in most parts of it containing considerably more gelatine. It has also an appreciable quantity more water, and the meat is whiter owing to the portion of blood left among its fibres containing a smaller quantity of red globules. About London a calf is usually slaughtered when ten weeks old, when it will weigh as many imperial stones of veal (the offal being omitted). As gelatine is longer in being converted into chyme than fibrine, veal is less readily digested than beef; and the same may be said of the flesh of most young animals. 2. *The Sheep* (*Ovis aries*). Mutton differs probably in only some trifling peculiarities from beef. Among these is that its retained blood contains fewer globules, and is therefore not so dark-coloured. Sheep are occasionally kept for four or five years, and occasionally longer, before they are considered fit for the butcher; but the great majority of those sent to the market (and their meat cannot be distinguished from older ones) are not much more than two years old. By far the best mutton is that of the wether, next that of a young ewe, then of an old ewe, and the worst of all that of a tup. The offal of a sheep is to the part saleable as food as one to three. Perhaps 120 pounds may be stated as the weight of an ordinary sheep's carcase. Of the several breeds, the Leicester sheep is the largest, and the one that comes earliest to maturity; but its flesh contains a large, and indeed excessive, quantity of oleaginous matter, mixed with the muscular fibre; and this renders the meat heavy and unpalatable. But as Leicester sheep soon become fat, and at a very early age, and attain, moreover, a very large size, the breed is a favourite one with the farmers. The Cheviot and Southdown (the two breeds are dietetically analogous) are smaller than the preceding, have darker meat, less fat, and are in every respect superior. The black-faced and Welsh varieties are still smaller, have less fat, and their flesh is much darker. Their flesh, too, has a particular, and, to most people, a very agreeable, flavour, owing probably to some peculiar oil in the fat. If well fed, they are, contrary to a popular opinion, in perfection when about two years of age. The flesh of lambs differs from that of sheep in containing more gelatine and water, and less fibrine. It is therefore less easy of digestion. 3. *Goat and Kid* (*Capra hyrcus*). Formerly goat-flesh was much used, and in modern Italy and the Peninsula it still is; but in this country the use of goat-flesh is confined to a few localities in the Highlands and in Wales. Kid-flesh is probably very analogous to that of lamb. 4. *Deer* (*Cervus*). Three kinds of venison are used as food in this country—that of the fallow-deer, which is considered the best; that of the larger stag; and that of the roebuck. All venison is darker than any other meat, owing, probably, to its retaining more blood corpuscles; and in flavour it resembles that of black-faced sheep. Fallow-deer and stags are considered to be in perfection at four years of age, and are not good food for three or four months after August. Venison has less fat than even black-faced mutton. 5. *Hog* (*Sus scrofa*). Of all quadrupeds whose flesh is employed as food, the hog is perhaps the most profitable. In the course of a twelvemonth it attains a large size (often 20 stones, or indeed much more). From its sedentary habits it wastes far less flesh, and consumes less of the carbon of its food, than any other of our domesticated animals, and has likewise a far less proportion of offal to useable meat than any other animal. Thus a pig that, when alive, weighed 199 lb., yielded a clean carcase that weighed 139 lb. (*Stephens.*) A well-fed hog, too, contains a large proportion of oleaginous matter separate from its muscles; and its physiological action when employed as food, in the form of bacon, is mainly to supply carbon. This fat also, when separated from its cellular tissues, differs from most other animal fats in containing more oleine, and is hence much used in cooking. For the same reason, the flesh of hogs when salted is less dry than that of any other salted meat. Fresh pork contains about 19 per cent. of albuminous matter, 1½ of salts, and more than 78 of water. 6. *Hare* (*Lepus timidus*). From its very active habits, the hare consumes the carbon of its food, and hence deposits no fat. For some reason or other, partly from its never having been bled, the blood is retained in great quantities among the muscles, and this makes the flesh very dark-coloured, but at the same time renders its infusion in soup very nutritious. Hares are not good food from February to August, that being their breeding-time. Hares weigh from 3 or 4 lb. to 10 or 12. The Alpine hare (*Lepus variabilis*) is smaller than the common hare, from which it may at once be known by its shorter ears and white fur in winter; and the colour of its flesh is intermediate between that of the common hare and the rabbit. 7. *Rabbit* (*Lepus cuniculus*). The wild rabbit, like the hare, has no fat, and its flesh is much whiter. It is used almost all the year round. A common weight is about 3 lb. Tame rabbits grow to a much larger size, and often contain fat. Of hares and rabbits, the eatable portion amounts perhaps to 50 per cent. of the original weight of the animal.

b. *Birds*. In birds that use active flight, or have been intended to do so, as partridges, fowls, &c., the pectoral muscles are whiter and drier, and are considered better than those which move the legs; but the reverse of this is usually held to be the case in aquatic birds, as ducks, which use principally the leg muscles. The cooking of the entrails of a woodcock, and the inducing in the goose an enlarged and diseased state of the liver, are also practices, but surely not very commendable ones, of epicures. 1. *Fowl* (*Gallus domesticus*). As compared with beef, the flesh of the fowl contains a little less water, only a fraction per cent. less of albuminous matter, and a greater proportion of salts. Hence, as a flesh-forming product, fowl is more nutritious than beef, but it is deficient in oleaginous or carbon-supplying matter. 2. *Turkey* (*Meleagris gallopavo*). Young turkeys about nine months old often weigh from 15 lb. upwards. In chemical constitution and in physiological action the flesh of a turkey is probably nearly identical with that of the common fowl. There are three varieties of turkeys—the black, the white, and the mottled gray. Of these the black is the hardiest, and is also thought to yield the best food. 3. *Guinea-fowl* (*Meleagris Numida*) very much resembles the turkey in the properties of its flesh, but owing probably to its semi-wild habits, it has somewhat of a game flavour, and is used as a substitute for game when game is out of season. 4. *Peacock* (*Pavo cristatus*). The flesh of the old pea-fowl is coarse and ill-flavoured, but the young bird is palatable, though rarely used as food. 5. *Partridge* (*Perdix cinerea*). The flesh of this and the four following birds has a peculiar flavour, arising doubtless from something introduced into their system by their food. There are two kinds of partridge, the common one and the red-legged partridge. They are only used from September to February. In common with other game, partridges, when long kept, acquire a peculiar smell and bitter flavour, both probably owing to kreatine. A partridge, with its feathers and entrails, weighs generally somewhat less than 1 lb. b. *Black-cock* (*Tetrao tetrix*). This beautiful and delicate bird is in season from the 20th of August to the 10th of December. It feeds pretty much on mountain berries, heath tops, and birch tops, which probably communicate part of its peculiar flavour. A cock weighs about 1 lb. The female (called a *gray hen*) weighs about 2 lb. 7. *Pheasant* (*Phasianus colchicus*). Except in its larger size, this bird resembles dietetically the partridge. It is in season from the 1st of October to the 2d of February. 8. *Grouse* and *Ptarmigan* (*Lagopus scoticus* and *vulgaris*). The red and white grouse live very much upon heather, which communicates to their flesh its peculiar flavour. Each weighs when killed about 1¼ lb. The capercailzie, *Tetrao urogallus*, (sometimes called woodland grouse) is perhaps extinct in the country, but sometimes appears in the market. One will weigh from 7 to 12 lb. 9. *Quail* (*Coturnix vulgaris*). This small bird resembles the patridge in flavour, and is in season from May to October. 10. *Duck* (*Anas boschus*). The flesh of aquatic birds is still darker than that of the game birds noticed above, this being owing to their muscles retaining more blood. Also, when in condition, they have a good deal of fat underneath their skins. As their lean is quite as nutritious as that of fowls and game, and as they contain this oleaginous matter in addition, they are more valuable as nutritive agents. The duck is in best condition in autumn; but ducklings are sold earlier. A common weight of a full-grown tame duck is 2½ or 3 lb. The wild duck is smaller. Wild ducks taken near the sea have usually a fishy taste, derived from their food. The *widgeon* (*Anas penelope*) is a species of wild duck. Its flesh is dark and dry, and is by many esteemed, but it is often fishy. Its average weight is 1½ lb. The *teal* (*Anas crecca*) is a still smaller kind of wild duck, the flesh of which is thought much superior to that of the widgeon. It is below 1 lb. in weight. Widgeons and teal are fat and in season at the end of the year. 11. *Goose* (*Anser palustris*). In common with that of most aquatic birds, the flesh of the goose seems to contain some peculiar matter, perhaps oleaginous (although this is quite contrary to what happens in birds), but the nature of which is unknown. A goose weighs (without feathers and offal) 6 lb. and upwards. The *Solan goose*, as it is called (*Pelicanus bassanus*), is really a pelican. It is caught on the Bass rock in the Firth of Forth, and in the Hebrides. It is salted and smoked. The flavour is very fishy. One weighs about 7 lb. A very analogous bird is the *puffin*, which is also salted, but, like the solan goose, it has a very fishy taste, and its use as food is almost wholly confined to the poor. They are chiefly captured for the sake of their feathers. 12. *Pigeon* (*Columba*). The flesh of the different kinds of pigeon, and of the lark (a bird be-

longing to a different natural family), is intermediate between that of poultry and game both in colour and flavour. As rich in albuminous matter it probably ranks high. The flesh of the pigeon indeed contains $21\frac{1}{2}$ per cent. of albuminous matter, and is therefore, as a flesh-forming article of diet, not only more nutritious than beef, but indeed more so than any article of animal food. Only the young (before they fly) of the domesticated pigeon are used at table. 13. *Woodcock* (*Scolopax rusticola*). This and the following four birds are waders, and their food consists of aquatic insects, small fishes, and the like. Their flesh is considered delicate; but it has not been subjected to analysis. A woodcock weighs 12 oz., and is in season from October to March. The common snipe, jack-snipe, plover, and landrail, are only considered fit for table when fat, which is at the beginning of winter, and during that season. The *bustard*, of the family of CURSORES, is now nearly or altogether extinct in this country. A few are sometimes yet caught in France, and sell very high. 14. *Rook* (*Corvus frugilegus*). The only predacious bird that is used for food is the young rook, and this but to a small extent. Its flavour is peculiar, and to many persons far from agreeable. 15. *Eggs*. The eggs of birds are a rather important article of diet. They resemble one another very much in composition and in their physiological action, and the several kinds probably do not materially differ from each other, save in containing some small amount of a peculiar volatile oil. A bird's egg essentially consists of shell, a membrane lining it, a white or albumen, and a yolk. Besides these, the yolk contains a membrane, the chalaza, which, as a dietetical agent, may be altogether overlooked. The shell is composed of a little animal matter, and phosphates of lime and magnesia, with 97 per cent. of carbonate of lime. The white of a common hen's egg is composed of water, 8·0; mucus, 4·5; albumen, 15·5. It also contains about 4 per cent. of inorganic ingredients (omitted in this analysis). These are sulphur, phosphorus, chlorine, potassa, soda, lime, and magnesia. The yolk contains, water, 53·73; albumen, 17·47; oil, 28·75. This oil contains 90 per cent. of oleine and only 10 of stearine. There is also a colouring principle, and nearly 6 per cent. of ash, the composition of which is much the same as that of the white, but it contains a greater proportion of phosphorus and (according to Liebig) iron. From these analyses it will be seen that eggs are extremely nutritious, being rich in albuminous and oleaginous compounds. The eggs of different birds probably contain a little volatile oil peculiar to each species, upon which their characteristic flavour depends.

c. *Reptiles*. Although several species of reptiles are used as food in other countries, the only one ever so employed in this is green turtle (*Testudo myas*), which is now regularly imported from the West Indies. It is particularly valued for a green gelatinous substance, commonly but erroneously termed its *fat*. In this country turtle is almost exclusively made into soup, but in the West Indies it is made into steak, &c. Turtle contains much gelatine and little fibrine. It probably, in a nutritive point of view, resembles, but is inferior to, veal. Vipers were formerly used in this country as a remedy for consumption, and a receipt for making viper-broth was once contained in the pharmacopœia. A species of frog is used as food on the Continent, but it is perhaps never eaten in this country. Indeed here the animal is rare.

d. *Fishes*. Fish constitute an important and economic article of food. The result of various analyses of fishes is to indicate that their muscles contain nearly but not quite as much of albuminous proximate principles as the flesh of quadrupeds, and fully as much of saline ingredients. Hence as flesh-producing articles of diet they are nearly equal to beef, &c. Some of the fishes, as trout, salmon, &c., contain also much oleaginous matter; but in others, as cod, haddock, &c., the oil is entirely confined to the liver. This latter class of fishes does not afford so much carbon to the system for respiratory purposes. Fish are in season before spawning, and for some time after they have spawned they are not good; but as most fish resort to the deep water after spawning, they are seldom caught in this state. Not only is recently-spawned fish flabby and tasteless, but it is sometimes positively unwholesome. Fish in tropical countries have sometimes proved poisonous, probably from the nature of their food. It is, however, certain that in this country no fish in season is unwholesome, although the barbel and the pike have for long been considered injurious. The following is a short account of the various species of fish commonly employed as food in Great Britain. 1. *Lamprey* (*Petromyzon marinus*). The sea lamprey is an oily and fibrous fish, whose bones are composed of cartilage (having no osseous matter). It is about two feet long. It ascends the rivers from the sea to spawn in spring, and is then in season. It is considered a great delicacy. It is not a common fish in Britain, only occurring, at least abundantly, in some southern rivers, but in many European rivers they occur so plentifully that they are salted and barrelled. There is also another smaller species. 2. *Dog-fish* (*Scyllium canicula*). This is a member of the shark family, and is very often caught in the herring-nets on the Scottish coasts. It is an oily and fibrous fish, and has a cartilaginous skeleton. Dog-fish are dried and used as winter food by the poorer people of the northern coasts. From their composition they are very nutritious, but they have a strong, disagreeable taste. 3. *Skate* (*Raia batis*). The larger skate live in deep water, and are seldom caught; but even the smaller ones in the shallows have been known to weigh 200 lb. Those commonly taken weigh perhaps from 6 to 20 lb. The flesh, from its containing oil, is very nutritious. Skate is in season from July till nearly the end of winter. 4. *Thornback* (*Raia clavata*) may be known from the skate by having spines upon the back, and it is smaller, seldom exceeding two feet in length. The young ones are called maids. The flesh resembles that of skate. 5. *Sturgeon* (*Acipenser sturio*). This fish sometimes ascends our rivers, and gets entangled in the salmon-nets. These generally are from 4 to 8 feet long (sometimes longer), and occasionally weigh 300 lb. Sturgeon is in season in winter and spring. The skeleton is gelatinous. Its flesh nearly resembles the taste of veal, and is much esteemed. The salted roe of the sturgeon constitutes *caviare*. It is sometimes imported to this country from Russia. 6. *Salmon* (*Salmo salar*). The salmon begins to enter the rivers for the purpose of spawning in autumn, and the parent fish return to the sea during the months of February, March, and April. The hatched young ones follow in April, May, and June. The salmon is in greatest perfection when ascending the rivers; but there is such a demand for salmon, that it has been found necessary to make enactments, rendering the taking of salmon legal only in certain seasons. All salmon fisheries north of the Tweed open on the 1st of February, and close on the 14th of September. The Tweed fishing opens on the 15th of February, and closes the 15th of October. As the spawn is deposited from October to February, this keeps up the breed; but it is plain that some of these fish will be caught when they are not in season, being weakened by the spawning. From 6 to 10 lb. is a common weight of a salmon, though sometimes this fish attains a much greater weight. As salmon contain oleaginous principles mixed among its albuminous, it is very nutritious. A young salmon returning for the first time to its native river, and weighing from 3 to 6 lb., is a grilse. 7. *Bull trout* (*Salmo eriox*). This fish is not in much esteem. Its flesh is white. 8. *Sea trout*, or *salmon trout* (*Salmo trutta*). This fish is about 18 inches long, and weighs about 3 lb. Its flesh is red, and is considered very good. Its migrations and seasons are much similar to those of the salmon. 9. *Trout* (*Salmo fario*). This well-known fish is a permanent resident in our rivers. There are several sub-varieties of it, which differ mainly in their flesh being more or less of a reddish hue; but, in general, it is nearly white. The Gillaroo trout differs from the common trout in having a very thick stomach. Trout are in season from February to August, and when full grown are about a foot long, and weigh about 1 lb. Sometimes, particularly in weirs, they attain a much larger size. The char, another variety of the salmon, only occurs in one or two lakes. 10. *Smelt* (*Osmerus eperlanus*). This little fish is generally about 8 or 9 inches long, and weighs less than $\frac{1}{2}$ lb. It is remarkable for the great transparency of its body, particularly of its head, and for a peculiar odour, which is thought to resemble that of a cucumber. It is a sea fish, but enters the estuaries to spawn, and stays there from autumn till March. It is in season in November, December, and January. 11. *Grayling* (*Salmo thymallus*) is a migrating fish, leaving the sea in the end of autumn to ascend clear rivers, for the purpose of spawning. It should be stated, that there is some doubt if it really does live in the sea. It is in best season at mid-winter. Its flesh, which is firm and white, is considered to have a very fine flavour. It weighs about as much as a trout. The above six fishes belong to the salmon family, and by some naturalists are considered species of the same genus, *Salmo*. 12. *Herring* (*Clupea harengus*). This fish is one of the most useful that approaches our shores. Immense shoals of it appear off the Shetland Islands in April, and are succeeded by a still more immense shoal in June. These shoals extend southward on the east and west coasts of Scotland, and in localities on the eastern coast of England. Their purpose in approaching the estuaries and coasts is to spawn; and, like other fish, they are then in best season. The herring contains a large quantity of oleaginous matter mixed with its albuminous principles, and is very nutritious. A herring is about a foot long, and seldom weighs quite a pound. Herrings are extensively employed both pickled and dried. 13. *Pilchard* (*Clupea pilchardus*) very much resembles the herring, but has a rounder body and no teeth. It appears in vast shoals off the Cornish coast in July, and is occasionally caught in more northern seas. The flesh contains more oil than that of the herring. In Cornwall, during their season, they are so extremely cheap as to be sometimes used as a manure. The sardine, which in a pickled state is imported from the Mediterranean, seems to be a small pilchard. The fry of the herring and pilchard are sold indiscriminately under the name of sprats. There is, however, a distinct small species, the *Clupea sprattus*. All these

are pickled red with cochineal or red lead, and sold as pickled anchovies. They may be distinguished by always retaining more or less of their backbone in an osseous state. 14. *Shad* (*Clupea alosa*) ascends the Severn and Thames to spawn, and is in season in July. It is in no esteem. The white bait is by many considered to be its fry, although naturalists maintain that it is a distinct species, *Clupea alba*. 15. *Anchovy* (*Clupea encrasicolus*). This little fish is abundant enough on our own coasts for our own supply, but it is imported in a pickled state from the Mediterranean. During the pickling it is boiled, and its backbone is quite dissolved. 16. *Pike* (*Esox lucius*) is a fresh-water fish that inhabits our rivers and lakes. A full-grown one weighs from five to a great many pounds, and when under 2 lb. is called a *jack*. The pike affords a very dry food, and has no oil. The sea pike or gar (*Belone vulgaris*) is pretty often caught on our coasts, but is not esteemed. Its backbone, as in the viviparous Blenny, becomes green by boiling. 17. *Carp* (*Cyprinus carpio*). This fish, before the railways conveyed salt-water fish to inland parts, was in greater esteem than it is now, or probably ever will be again in this country. It is the fish that is most commonly bred in ponds. It weighs from 3 to 20 lb. Carps are in season from April to October. Other fishes of the same family (the Cyprinidæ) all fresh-water ones, are sometimes used as food, and may be here mentioned. The barbel inhabits English rivers, and grows to two or three feet long, but it is considered very indifferent food. The little gudgeon is caught during summer in shallow streams, and is regarded as very good. The tench is perhaps the best dietetical fish of the family. It sometimes attains a weight of 4 or 5 lb., but is usually under 1 lb. It is in season from May to October. The bream is another fresh-water fish that inhabits some of our lakes and sluggish rivers. In appearance it almost resembles a flat fish. It is not much esteemed in this country, but in France it is. It spawns in July, and is in season two or three months before, but some regard it as in best season in September just after it has recovered its strength. It weighs from ½ lb. to 3 or 4 lb. The chub, the roach, and the dace are all river fish, and in little estimation. Their flesh appears to contain an excess of water which perhaps renders them insipid. Walton, however, maintained that the chub owed its bad reputation to ignorant cookery. 19. *The Cod family*. Members of this very important group afford large and most valuable supplies of food, both in a fresh and salted state. They all contain a due proportion of albuminous matter, but their muscular part has no oleaginous principle, all their oil being contained in their livers; although perhaps the milts contain a little. a. *Cod* (*Morhua vulgaris*, or, old name, *Gadus Morhua*). This, one of the most numerous of fishes, is abundant on many of our coasts, and (salted) is exported in abundance from Zetland, Iceland, and Newfoundland. It spawns in spring, and is therefore in season in the winter months, but it appears to recover from spawning sooner than almost any other fish, or at least large fish, and is good during the greater part of summer. It weighs from 6 to 20 lb., and occasionally more. Young cod, or codlings, are far more watery and insipid than the mature cod. Indeed many that are sold as such are really young coal-fish. The swimming bladders of the cod are also salted, and used as food. They consist almost entirely of gelatine. b. *Haddock* (*Morhua æglifinus*, or *Gadus æglifinus*) is much smaller than the cod, seldom being longer than 1½ ft., or weighing more than from 2 to 3 lb. Its flesh, however, is more delicate than that of the cod. Haddocks are in season from May to September. They are used fresh, slightly salted, or smoked (then called Finnan haddocks). c. *Ling* (*Molva vulgaris*, or *Gadus Molva*) is taken in considerable quantities on our northern and north-eastern coasts. It is much slenderer than the cod, and, like it, is eaten both fresh and salted. Contrary to the general opinion, it is in both ways superior to the cod. It spawns in June, and is in perfection to the end of May, and it may be known to be in season by its liver being white. It seems probable that a great many of the so-called cod sounds are ling sounds. The ling attains the same weight as the cod. Dried cod is very often sold as dried ling. d. *Tusk and Hake* (*Brosmius vulgaris*, and *Merluccius vulgaris*, or *Gadus Brosmius* and *Gadus Merluccius*). The first of these is common in the north and the other in the south. They are both caught along with ling and cod, and are about the same size. They are generally dried and salted. Another species of the same family, and of the same genus as the tusk, is the coal-fish, which in certain localities, as the Scottish islands, is extensively used. It has various names. In Scotland a young one is called a podley and an old one a sethe. Considerable quantities of cod, ling, tusk, hake, and coal-fish are salted and dried, and largely exported. It is called stock-fish; and as most of the water is expelled it is an extremely concentrated and nutritious article of diet, though not very digestible. e. *Whiting* (*Merlangus vulgaris* or *Gadus Merlangus*) is the most delicate fish of its family. It spawns from March to September, and is therefore in best season during the two first months of the year. It is however pretty good towards the end of the year. In the south of England it is frequently salted, and is there called "buck-horn." A whiting is usually about a foot long, and seldom weighs more than 1 lb. 20. *The Flat fish*. These fishes belong to the Pleuronectidæ, and are easily recognised by their flattened form, and by having both their eyes on one side. They are much esteemed for their delicate flavour. The oleaginous principles are confined to their livers, and hence they only furnish albuminous matter, but they contain (at least some of them) more than 20 per cent. of it. a. *Plaice* (*Platessa vulgaris*). This and the two following platessæ are known from the other flat fish by each jaw having a single row of obtuse teeth, a spine at the beginning of the anal fin, and a rounded tail. The body is rhomboidal, and the eyes are generally on the right side. The plaice has a smooth body, with six tubercles on its head. It is considered one of the most flabby and worst of the flat fish. It weighs from ¾ of a lb. to 3 or 4 lb. b. *Flounder* (*Platessa plesus*). The body of the flounder or fluke is smooth, and it has a band of sharp spines on the side lines and at the junction of the anal and dorsal fins with the body. It is in season from January to March, and from July to September. c. *Dab* (*Platessa Limanda*) has scales, and is rather less and thinner than the flounder. It spawns in May, and is out of season in that and the following month. d. *Holibut* (*Hippoglossus vulgaris*) may be known by its slender pointed teeth, its elongated body, and lunated tail. It is a large fish, sometimes weighing 200 lb. Its flesh is white and good, although by many not much esteemed. In Scotland it is very frequently sold as turbot. Holibut is best in season in March, April, and May. e. *Turbot* (*Rhombus maximus*). The genus rhombus may be known by their thick-set pointed teeth, eyes being generally placed on the left side, and entire mouth. The turbot itself is the most esteemed of all the flat fishes, and may be known by its numerous round and hardish tubercles, particularly on its coloured side. Its under side is cream-coloured, and on this side it has no scales. It has no red spots, which at once distinguishes it from the plaice. It is often two feet long, and weighs from 12 to 20 lb. It appears to be in season all the year round. Its flavour, which is so much esteemed, probably depends upon the crustaceous animals upon which it feeds. Turbot is the dearest of all fish. Among the Scotch fishermen it is called *bannock fluke*. f. *Brill* (*Rhombus vulgaris*) may be distinguished from the turbot (which as food it almost equals) by its not having the tubercles on its coloured side, and by its colouring, which is fuscous, being spotted with brown-yellow and white. It has scales, too, on both sides. Brill is considerably smaller than turbot, from 1 to 3 lb. being a common weight. It is exposed for sale nearly at all seasons indiscriminately. Its Scotch name is *Bannet fleuk*. g. (*Solea vulgaris*). The genus Solea is distinguished from the foregoing by its twisted mouth, and by the jaws of the eye side having no teeth. The sole inhabits the sandy shores of our island, and its meat is very much esteemed, being firm, white, and delicate. It spawns towards the end of February, and is out of season for a few weeks afterwards. A sole weighs from ¾ lb. upwards. 21. *Eel* (*Anguilla vulgaris*) is one of the fishes that contains oil amongst its muscular texture. In shape it resembles a snake. Its scales are not visible to the naked eye. It is considered to afford good food, but to be difficult of digestion. It is always in season. A pound is a common weight of an eel, although eels very often attain a much larger size. The *conger-eel* (a permanent inhabitant of salt water) may be known by the margins of its fins being black. It grows to an enormous size, sometimes attaining a weight of 100 lb. In the Peninsula it is dried and powdered for the purpose of putting into ragouts, but it is seldom eaten in Scotland. The little *sand-eel*, common on our sandy shores, is properly a launce. 22. *Wolf or Cat-fish* (*Anarrhichas lupus*) is common, and may be recognised by its very ugly appearance, and by its dorsal fin extending the whole length of the back. It furnishes, nevertheless, very good food. In Scotland it is improperly sold as John Dory—a fish altogether different. Its common weight is 3 or 4 lb. 23. *Perch* (*Perca fluviatilis*). The common perch may be known by the spines of its first dorsal fin. It spawns in the beginning of May, and is out of season for a few weeks afterwards. It is considered one of the best of our fresh-water fishes. Sometimes it attains a weight of several pounds, but one pound is perhaps more than an average. 24. *Gurnard* (*Trigla cuculus*). This (like other members of the genus) is common on the English and Irish coasts, weighs about 3 lb., is in season from October to the end of winter, and is considered to afford good food. 25. *Red Mullet* (*Mullus surmuletus*) is taken on the south-western coasts of England, but rarely on our northern shores. It is about a foot long, is in best season in May and June (although sold at all seasons), and is regarded as very excellent food. The *gray mullet* (*Mugil capelo*) is a fish of a different genus, and is abundant on the south and west coast of England. It is 1½ feet long, and its flesh is esteemed. The roe is sometimes made into caviare. It is one of the few fishes that are sometimes artificially fattened. 26. *Mackerel* (*Scomber vulgaris*) one of the most beautiful and delicious of our fishes, is in season from May to the end of summer. It is more common in the southern than in the northern part of our

coast. For some reason not well understood, it is apt to become rapidly putrescent after it is taken from the sea. An ordinary length is from 12 to 16 (sometimes even 20) inches, and the weight from 1 to 1½ lb. The *tunny mackerel* or *common tunny* (*Scomber Thynnus*) is sometimes taken on the western coast of Scotland. It is from 3 to 6 feet long, and like sturgeon its flesh resembles that of quadrupeds. It is much esteemed in France. 27. *John Dory* or *Doree* (*Zeus Faber*) is not a common fish, but is occasionally caught on the Cornish and Devonshire coasts. It is a very ugly animal—its head being disproportionately large for its body. It is very much esteemed. It is in season at the end of spring, and commonly weighs 4 or 5 lb. Unless kept for a day or two after being caught, it is tough.

e. *Invertebrated Animals.*—a. *Crustaceous animals having shelly coverings and feet.*—1. *Lobster* (*Astacus marinus* or *grammarus*). This animal, improperly called a shell-fish, inhabits all the northern seas. The full-grown ones are in season from October to May, but small ones are eaten all the year round. Lobsters are of a blue-black colour, but when boiled their shell assumes a bright red. The male is known by its narrower tail, and is most esteemed, particularly during winter, but the female is found superior for some culinary purposes. The muscular parts of the lobster and of the three succeeding animals contain (we have no exact analysis) fibrine, gelatine, and a peculiar principle to which they probably owe their flavour, and also perhaps their indigestibility. The common *cray fish* (*Astacus palinurus*) is similar but inferior to the lobster. 2. *Crab* (*Cancer pagurus*). The crab is very abundant on all our rocky shores. It is in season all the year except May, June, and July, although individuals may be obtained fit for the table at any season. The male is usually preferred. 3. *Shrimp* (*Crangon vulgaris*). This little animal is common on our sandy shores. It is nearly transparent; but when boiled it becomes of a brownish-red colour. 4. The prawn (*Palæmon serratus*) is analogous to the shrimp, but considerably larger. b. *Molluscous animals without feet.* 1. *Oyster* (*Ostrea edulis*). This much-esteemed animal is in season from September to April. In May it spawns, and requires all the summer to recruit its condition. Oysters are abundant on our shores, where they stick to rocks or other solid bodies, but they are often collected and fattened in beds. They contain about 12 per cent. of albuminous matters, and are therefore moderately nutritious. 2. *Cockle* (*Cardium edule*). This little bivalve burrows in the sand about low-water mark. It is in season in spring, and is palatable. The pecten, the razor-fish, the periwinkle and whelk, are analogous molluscous animals which are sometimes used as food, chiefly by the common people. 3. *Mussel* (*Mytylus edulis*). The sea-mussel lives in flocks on hard ground above low-water mark. It has a peculiar beard by which it sticks to the sand or rock. It is in season in autumn and in spring. It is occasionally poisonous.

f. *Insects.*—Perhaps with the exception of the locust and some larvæ no insect is used by man as food. *Honey*, however, the produce of the bee, is largely used by man. It is probably somewhat modified from its original state in the flower by secretions from the bee. Honey consists of two kinds of sugar, one that will crystallize and therefore be separated in the solid form, and one that will not. It also contains colouring and odorous matter (and some other matters) derived from the flowers upon which the bees feed, and its flavour consequently varies with the plants from which it is gathered. Fermented honey is *mead*—a drink now little used. Honey may be used as sugar, and supplies the system with carbon.

g. *Aqueous Aliment.*—*Water*. As nearly four-fifths of the body of man consists of water, this fluid is a necessary ingredient in his food. All the so-called solid matter that he eats, as has been before stated, contains it most abundantly. It is almost certain that a portion of the water taken into the stomach is decomposed in the system, and yields oxygen and hydrogen. Spring water usually contains a small quantity of saline ingredients derived from the rocks through which it has flowed. When it contains much lime or magnesia it is said to be *hard*. It often too contains a little organic matter.

h. *Condiments.* Only one condiment, common salt (the action of which is inexplicable, none of the theories proposed regarding it being satisfactory), is absolutely necessary, but in civilized countries several others are used for the purpose of promoting the appetite and stimulating the digestion. And notwithstanding the stereotyped outcry, there can be no doubt but that if used in moderation they are conducive to health. 1. *Common salt* is obtained from sea-water and also from salt mines, which are portions of beds of extinct seas. It is indispensable to all food, but it is not known whether it acts as food itself (to afford sodium and chlorine) or for some other purpose. Perhaps it is necessary to form the hydrochloric acid of the stomach. However this may be, every adult man consumes a considerable quantity of it. Two kinds are known in commerce, bay salt or large crystallized salt, and white, basket, or small crystallized salt. Salt is also used for preserving articles of food, and for this purpose the large or bay salt is preferred. Many specimens of salt contain magnesia, but it is essentially composed of chlorine and sodium. The notion that salt or salted meats produce scurvy is erroneous. When this disease breaks out at sea it is not the presence of salted food but the absence of fresh vegetables that excites it. 2. *Vinegar.* What is sold in the shops as vinegar is diluted acetic acid. Four strengths are sold, called Nos. 18, 20, 22, and 24; No. 22 is the best for domestic purposes. Vinegar is often adulterated with sulphuric acid. A small quantity of it is probably assimilated and supplies the system with carbon. It is frequently flavoured with capsicum, tarragon, &c.; and pickles, although the vegetables in them go for something, are essentially spiced vinegar. The use of vinegar as an antiseptic will be afterwards considered. When fresh vegetables cannot be regularly obtained, as in voyages, a liberal allowance of vinegar is found very conducive to health (see Section V.) Lemon-juice, which is a diluted solution of citric acid, is also used advantageously for the last-mentioned purpose. 3. *Spices.* Nearly all the spices are natives of tropical countries, contain aromatic and stimulating essential oils, and yield little or no nutriment, but are unquestionably useful in artificial states of society as promoting appetite and digestion. The most important of them are the peppers, turmeric, cinnamon, cloves, nutmeg, mace, ginger, and pimento. 4. *Seasoning* and *Sweet Herbs.* These resemble the preceding, but are natives of our own climate. They all contain an essential oil, and unquestionably are, if taken in small quantities, useful. The most common of them are mustard, horse-radish, parsley, tarragon, thyme, sage, mint, savoy, and tansy. Capers, which belong to this class, are imported in a salted state from the Levant. 5. *Sauces* and *Compound Condiments.* These are also useful flavouring ingredients. Catsup is the seasoned juice of mushrooms, and sometimes of green walnuts. Soy ought to be the juice of the *Dolichos Soja*, a Japanese plant, but is usually a mixture of fermented pease-juice, catsup, and spices. Anchovy sauce is a solution of anchovies and spices. Curry-powder is a mixture of turmeric, pepper, coriander, ginger, and other flavouring ingredients. The various sauces of the shops have for their base catsup, and their difference consists in their seasoning ingredients.

III.—*The Modes of Preparing Food for Human Use, and the rationale of their respective actions.*

Most animal and vegetable articles of food are exposed to heat before being used. The effect of this is in albuminous compounds to coagulate the albumen, to promote the formation of osmazome and kreatine, and to expel a portion of the water (and fat, if any be present). Heat applied to starchy compounds (if, as is always the case, water be present) causes them to swell, and the starch grains split, and form more or less of a homogeneous mass, and in this way they become more palatable, and also in a state that the digestive juices can act better upon them. And vegetables too, in some manner which it is not easy to explain, lose by the application of heat a great part of their acidity, and sometimes sugar is formed in the process. The operations of cooking may be divided generally into roasting, baking, broiling, frying, boiling, and stewing, and to these may be added the making of bread, the processes connected with vinous fermentation, distillation, and vinegar-making. 1. *Roasting.* Professor Wallace many years ago made some experiments relative to the loss of weight sustained during this process, and he found that taking 10 lb. joints, the average loss of 100 lb. of beef in roasting was 32 lb., of necks of mutton 35 lb., of shoulder of mutton 31⅓ lb., and of legs of mutton 21⅓ lb. But in Professor Wallace's experiment fatter meat was probably used than what is customary now; and he did not ascertain the amount of bone. The inquiries of Donovan are more instructive, and the conclusion that he came to is that the loss in roasting in the best piece of beef (as the sirloin), is 19½ per cent., in a fore-quarter of lamb 22⅓, in a goose 19½, in a turkey a little more, in a duck 27⅕, and in a chicken 14⅜ per cent. The proportion of the bones in a roasted joint of meat, as ascertained by the same experimenter, is also important. He took a piece of the longer ribs of beef that weighed 11¼ lb. This when roasted lost 2 lb. 6 oz., of which 28 oz. were water and 10 fat, &c. The meat was then dissected from the bones, and these were found to weigh 16 oz. Consequently, of the original joint which weighed more than 11 lb. there was less than 8 lb. of meat; so that if it was bought at 8½d. a lb., the roasted beef that could be actually consumed would cost more than 1s. a lb. Part of a sirloin of beef that weighed 12 lb. lost by roasting 44 oz., of which 27 were water and 17 fat, &c. The bones weighed 2 lb., and the beef that was actually suitable for eating weighed 7¼ lb. Hence if the cost of the joint were at the rate of 8½d. per lb., the value of the roasted meat would be 1s. 2d. per lb. A leg of mutton that weighed when bought 9¼ lb., lost when roasting 1 lb. of fat, &c., and 14 oz. of water. The bone weighed 16 oz. Only 6 lb. 6 oz. were left, and if the butcher had

charged 8d. per lb., the cooked meat would cost more than 11d. per lb. Lamb, it was found, lost a little more by roasting than mutton. A goose (not stuffed) prepared for roasting weighed 5½ lb. When roasted it was found to have lost 18 oz., and the bones weighed 12 oz. The edible part that remained, therefore, if the goose sold at 1s a lb. would be worth 1s. 8½d. A turkey properly trussed weighed, including its liver and gizzard, 6 lb. 11 oz. It lost 20 oz. in roasting, and its skeleton weighed nearly 14 oz., the weight of its edible part being 4 lb. 10 oz. Had the original price of the turkey been 5s. the value of the roasted meat would be 1s. 1d. According to the same authority, a duck when prepared for roasting weighed 1 lb. 10½ oz. In roasting it lost 6½ oz., and the bones weighed 4 oz. The edible portion was therefore only about 1 lb.; and if the duck cost 2s. or 1s. 8d., the food it yielded would be this sum per lb. A fowl weighing 1½ lb. lost 3 oz. when roasted, and its skeleton weighed 3½ oz. The edible portion therefore was 16½ oz. At the price fowls commonly sell at, the cost of the roasted meat would be 1s. 6d. per lb. 2. *Baking*. The difference between roasting and baking consists in this, that in the latter process there is no free current of air allowed, the result of which is, that less water is evaporated, and that also less oil is expressed out. Hence baked meat is partly roasted by the hot air, and partly boiled in its own water and fat. Wallace found that 100 lb. of meat lost in baking 30 lb., being 2 per cent. more than the same quantity, in his experiments, lost when roasted. 3. *Broiling*. This is a very rapid mode of roasting, by means of applying more intense heat, the substance to be cooked being placed immediately over instead of before the fire. The albumen at the outside of meat so cooked is immediately coagulated, and a little crust formed, which (unless the meat be pricked with a fork), prevents the escape of much water, fat, or gelatine. 4. *Boiling*. The following experiments of Donovan's show the loss sustained by boiling various articles of food, and consequently the value of the soup. A piece of flank of beef weighing 10 lb., had 8 oz. of bone. It was boiled and found to lose 23 oz. Supposing, therefore, it cost 6d. per lb., its price when cooked would be 7½d. A leg of mutton weighed 9¼ lb. When boiled its bone including its shank weighed 1 lb., and the loss of the meat was 1 lb. 2 oz. If it cost 8d. a lb., it would be worth when boiled 10¼d. A ham without its shank that weighed 8 lb. was boiled. The bone weighed 8 oz, and the loss by boiling was 1 lb., and by skinning and browning (a partial roasting) ½ lb. The meat that was left therefore weighed 6 lb. Had the ham cost 10d. per lb., when cooked it would be worth 1s. 11½d. per lb. A piece of bacon that previously weighed 4 lb., lost by boiling 4 oz. The bone weighed 2¾ oz., and the skin and loss by boiling amounted to ½ lb. The edible portion weighed 3 lb. 1 oz. If it originally cost 8d. a lb., the meat when cooked would be worth 10½d. per lb. A turkey that weighed 4½ lb. and which cost 3s. 6d., lost 12 oz. in boiling, and its bones weighed 10 oz. The edible portion therefore amounted to 3 lb. 2 oz., and had cost at the rate of 13d. per lb. A chicken that weighed 1½ lb., lost 3½ oz. by boiling, and its bones weighed 4 oz. This left 12½ of meat, which, if the chicken cost 1s. 6d., was worth nearly 2s. per lb. A turbot that weighed 9 lb. and cost 7s., lost in boiling 8 oz. and its bones weighed 21 oz. Hence its edible part after cooking amounted to 11½d. per lb. The following table prepared from the same source shows the average loss from roasting and boiling:—

		per cent.			per cent.
Loss in roasting	beef,	19⅕	Loss in boiling	salt beef,	15
...	mutton,	24⅘	...	mutton,	10
...	turkey,	20½	...	turkey,	16
...	chicken,	14⅗	...	chicken,	13½

a. *Soup-making*. Soup is a decoction in water of a good deal of gelatine, some fibrine, albumen, phosphate of lime, other salts, and osmazome. The fibrine, however, rises to the surface and is skimmed off. Of course, vegetables, as will be seen by a reference to their chemical composition, yield exactly the same kind of soup as butcher meat or fish. In practice, however, a mixture of animal and vegetable matter well boiled is found to afford the most economical soup. Animal soup probably contains little albumen, but when vegetables are boiled down, their albuminous proximate principles are quite mixed up with the fluid. This is probably the reason that the vegetable or nearly vegetable soups so much employed by the labouring classes in Scotland and France are found to produce in their consumers such a high degree of material vigour. Soup also perhaps contains some kreatine and certainly generally lactic acid; and Liebig affirms that the addition of the latter (in the form of sour krout) improves the flavour of the soup; but the experience of English gastronomists at least scarcely confirms this opinion. The same distinguished chemist also affirms that chloride of potassium improves the piquancy of soup. 4. *Stewing*. By this method of preparing meat, less of the principles of the meat are absorbed by the surrounding menstruum, and the greater portion of the gelatine in particular remains among the coagulated albumen. Hence stewing is an economical form of cooking. 5. *Frying*. In this culinary process it is probable that a portion of the glycerine of the fat is decomposed, and that a new substance or principle is formed, which principle seems somewhat difficult of digestion. 6. *Bread-making*. Common fermented wheaten bread is made by mixing flour, water, salt, and some albuminous matter, either yeast or leaven (*i. e.* a piece of old bread), and placing the compound in a warmish situation. Two catalytic actions very soon begin; a portion, and the greater portion, of the sugar, is converted into alcohol and carbonic acid; the greater part of the former of these compounds is evaporated (by the after heat of the baking), but the carbonic acid gas is retained among the tenacious gluten, and produces the vesicular structure that characterizes ordinary fermented bread. Then some of the starch is likewise converted into sugar. If the alcoholic fermentation be allowed to go on too long, it runs into the acetous, and the bread consequently becomes sour. It is said that the salt employed in the mixture, besides communicating flavour, communicates stiffness to the dough, probably by abstracting some of its water. After these changes have taken place the bread is baked, the result being that a considerable quantity of water and the alcohol are driven off and the albumen is coagulated. 100 lb. of flour produce 139 lb. of bread; but the apparent gain is derived from the water that is used—the flour being diminished in quantity by the conversion of part of it into alcohol and carbonic acid. The baker often adds potato-flour and also alum to his dough. The latter adulteration makes the loaf whiter, but is highly injurious to the consumer. Brown or household bread differs from white bread, in the flour of which it is made containing more or less of bran. Rolls are made to ferment more rapidly than loaf bread by adding more ferment, and hence are more porous. None but wheaten flour is used in this country for making leavened bread, but formerly rye or black bread, still so common abroad, was extensively employed. For many years occasional attempts have been made to make bread spongy by adding to the dough, in place of yeast, hydrochloric acid and carbonate of soda. Carbonic acid is given off, which mixes among the gluten and makes the bread light, and chloride of sodium or common salt is left behind. In this manner the waste caused by the conversion of the sugar into alcohol is avoided. Properly prepared gingerbread is rendered porous in a similar manner. Carbonate of potassa and treacle are added to the dough. Treacle contains a free acid which combines with the potassa salt and liberates the carbonic acid. Some kinds of light bread are rendered porous by adding carbonate of ammonia to the dough, the ammonia of which is expelled by the heat of the oven; and some cakes are made light by the addition of carbonate of magnesia. Wheat flour is also used unfermented in various ways—as in pastry, biscuits, macaroni, &c. &c. (See BAKING). 7. *Wine and Vinegar Making*. Grape wine is now rarely made in this country, as the grape grown out of doors rarely contains sugar to afford an alcoholic mixture that is strong enough. Raisin wine, however, it is believed, is pretty extensively made, and the greater part of it sold as sherry. Domestic wines are made by fermenting the juices of currents, gooseberries, and other fruits, with the addition of sugar and tartaric acid, and frequently a little spirit. Vinegar is oxidated alcohol, and is usually prepared by fermenting a saccharine solution, and then exposing the diluted alcohol thereby obtained to the air.

IV.—*The Modes of Preserving Articles of Food from Decomposition.*

The elements that compose all living structures, vegetable or animal, are grouped together in obedience to certain laws of vital affinity. But this obedience is transitory, and whenever life departs from an animal or plant, they tend to, and ultimately always do, return to the dead world, and become subject to the laws of chemistry. The series of changes that they undergo in thus passing from one arrangement of their elements to another is termed putrefaction, and consists mainly in the following processes:—The carbon absorbs oxygen from the air, and carbonic acid is formed and given off; some of the hydrogen and oxygen unite together and form water, and another portion of the hydrogen unites with the nitrogen (if any be present) and forms ammonia, while another portion of it unites respectively with carbon, phosphorus, and sulphur, the results being carburetted, phosphuretted, and sulphuretted hydrogen gases, the last of which communicates a great part of the disagreeable odour of putrefying food. Very probably, too, kreatine, &c., are formed and decomposed during the putrefying process. An albuminous substance putrefies the most rapidly, owing to its albuminous compounds acting catalytically as a ferment. A purely saccharine or oleaginous substance putrefies much more slowly, and is only resolved into water and carburetted hydrogen, and hence has little bad smell. It often becomes previously converted into vinegar. In order, however, that putrefaction take place, two conditions are necessary—in the first place, water must be present, and it is indispensable, at

least for rapid putrefaction, 1st, That the alimentary matter be exposed to oxygen, or, what comes to the same thing, to air. This enables us to understand why one article of food putrefies so much sooner than another. If a piece of meat, for example, be exposed to the atmosphere, say in the month of September, along with a bone and a potato, the meat being fully exposed to the air, and containing a large proportion of albuminous matter and water, soon putrefies; while the other two—the one containing little water, and the other protected from the air by its skin, retain their structure for a number of months. 2d. Heat, in virtue of the power it possesses of removing its atoms from one another, strongly predisposes to putrefaction; so also does the presence of any other putrefying substance, which seems to act catalytically. This action may be counteracted by excluding the air or the water, and also by the use of certain antiseptic substances, as salt, sugar, vinegar, &c., the action of most of which, however, is to be explained by the property that they possess of acting upon air or of abstracting water. If meat appear likely to become tainted, it may be preserved for a few days by any of the following means:—It may be kept enveloped in a wet cloth, which in consequence of the evaporation produces cold; it may be slightly smeared over with pyroligneous acid; it may be surrounded by a little powdered charcoal, which absorbs the sulphuretted hydrogen and other decomposing gases; or it may be kept in an atmosphere of creasote. This last seems to be a most effectual plan, and Dr Stenhouse of Glasgow reports most favourably of its success, not only with himself, but also with a butcher who tried it. 1. Articles of food may be preserved from putrefaction for a very considerable time by expelling the water they contain by the action of heat. Indeed something of this kind is occasionally witnessed in nature; and in hot sandy deserts where rain seldom or never falls, the bodies of camels and of travellers are found undecomposed, and have probably been so for ages. Advantage is seldom taken in this country to preserve vegetables in this manner, although the kiln-drying of wheat and other grains is partly a process of this nature, and the usual manner of preserving sweet or pot-herbs is essentially so. Abroad, and sometimes perhaps here, apples and pears are sliced and put into a heated oven, so as to expel the water, and the fruit thus dried may be kept for a considerable time. The flesh of mammals is rarely so preserved in this country, but the Indians thus prepare *pemmican*, an imitation of which made of beef, but which is generally also smoked, has been employed in our Arctic expeditions. It was in this way the buccaneers preserved their beef. Portable soup is essentially a dried meat. It is made by preparing a strong beef soup from a bony piece, as the leg of an ox, skimming off the fat, and then evaporating the water. According to Liebig, the test for distinguishing the true extract of flesh from the spurious imitation, which consists almost entirely of gelatine, is that 80 per cent. of the true extract is soluble in alcohol, and only 4 or 5 of the gelatine cakes. 2. Many articles may be preserved from putrefaction by means of solidifying the water they contain by applying cold. Water becomes solid at 32°, and when the water of a structure has been thus converted into ice all putrefaction is impossible. Thus the fossil elephant that was found imbedded in Siberia was quite fresh although it had probably been so imbedded for thousands of years. This mode of preserving food, however, is not applicable to vegetables, for the starch of a frozen vegetable is almost certain to be converted by frost into sugar. But in cold countries, as in the north of Russia, Canada, &c., it is very extensively used as a means of preserving flesh, whole animals being often frozen, and thus kept throughout winter. If, however, frozen meat be not gradually and slowly thawed by being at first immersed in cold water, putrefaction comes on so rapidly that the meat is unpalatable. In this country butcher meat is seldom or never preserved in this manner; but fish, especially salmon, is so on a very large scale. Every salmon-fishery of any consequence in Scotland has an ice-house, and the salmon intended for the English markets are packed in the ice and thereby frozen or nearly frozen. In this manner they reach their destination in a fresh state. The fishmongers too preserve their other fish in a similar manner. 3. Articles of food may also be preserved from putrefaction by excluding them from air. This has long been done in a great variety of ways. The oldest and most imperfect of these is potting, which is usually performed by beating up the meat into a paste, then putting it into jars and covering it up with clarified butter. Another variety of meat similarly preserved is the common sausage. The exclusion of air, however, is only partial, and consequently sausages do not keep very long. This defect is obviated in the Bologna sausage by smoking the meat of which it is made. Long ago, Mr Boyle tried the experiment of keeping food in an exhausted receiver, and he found that no putrefaction took place; but the plan of preserving food by thoroughly excluding the air was scarcely carried into practice until 1810, when M. Appert (who seems to have been quite ignorant of Boyle's experiments) published his plan of effecting this, and received a reward for it from the French government. Since then his method, with some modifications of detail, has been extensively pursued. It consists in first coagulating the albumen of the animal and vegetable structure to be preserved by parboiling it, and thus attaining two ends, the coagulated albumen being far less disposed to putrefy than uncoagulated, and a great portion of air being drawn off; and secondly, in putting the parboiled food in jars or bottles (the latter in the case of liquids), and plunging these into boiling water, which expels a great portion of the remaining air contained in the food. Some air indeed always remains, but the oxygen of most of it combines with carbon and forms carbonic acid; why, it is not very easy to say. The jars are then hermetically sealed, and their imperviousness to air tested. At present, instead of bottles tin canisters are employed, and these have the additional advantage of collapsing a little from atmospherical pressure. As, however, some air is left, the food eventually putrefies. Meat prepared in this manner sells from 1s. 3d. to 2s. a lb., soup from 2s. upwards per quart, and milk at about 1s. a pint. The various plans followed for the preservation of eggs all depend upon the exclusion of air. A simple plan is to stop up the pores of the shell by smearing the eggs with some unctuous substance, as suet. Another mode is to pack the eggs in bran, salt, &c. A third is to boil them for a few seconds, and thus form a small layer of coagulated albumen underneath the shell. It should be observed that eggs are very apt to contract an unpleasant flavour from the readiness with which they absorb odorous effluvia. Thus, when packed in old straw, their flavour is frequently much affected. 4. Articles of food may be preserved from putrefaction by means of salt. This plan has been practised from time immemorial, and in this country, before the turnip culture allowed the farmer to furnish continuous supplies of butcher meat, was even much more extensively used than now. One part of the action of the salt is to abstract a great part of the water, another is to abstract the juices from the outside (thereby forming brine), and thus to envelope the meat in a hardened case which more or less excludes the air; but there is probably some other property of the salt of an antiseptic nature, the exact nature of which is not known. As all articles of food preserved by salt retain a portion of the salt in their texture, they are always a little firmer in their structure than the same foods unsalted. In the ordinary manner of salting animal food, about one-third of the juices, including some of the soluble albumen, passes off into the brine. If this statement be correct salted meat is of course much less nutritious than fresh. Liebig proposes to employ a salt that contains chlorides of calcium and magnesium. The lime and magnesia, according to him, unite with the phosphates of the juice and cover the meat with a crust or white froth of phosphates of lime and magnesia which effectually keep in the juices. It is generally believed among practical salters that the salt which occurs in large crystals or bay salt is preferable to the finer kind, and as bay salt is not so pure as the fine, this would appear to confirm Liebig's hypothesis. In salting a piece of meat or of fish, the salt is generally rubbed in, and the brine allowed to run off, and in this case it is then dried and frequently smoked. When the food is kept immersed in the brine it is said to be *pickled*. Vegetables are sometimes salted dry, but generally pickled. It is also very common to add nitrate of potassa or saltpetre in the salting of flesh. This substance acts as an antiseptic by abstracting water, but it also forms a compound of a red colour with meat. Sugar, another antiseptic, is also now commonly added to the salt and salt brine, and frequently also spices for the purpose of communicating a flavour. 5. Articles of food may be preserved from putrefaction by means of sugar alone. Sugar is a powerful antiseptic, part of its action being owing to its abstraction of water; but it also possesses a peculiar but inexplicable power of preventing a substance with which it is placed in contact from obtaining oxygen. Sugar, however, although much employed mixed with salt, is seldom used alone to preserve animal food; some fish, as salmon and mackerel, are occasionally so preserved, but the great application of sugar in this respect is to vegetables. Sometimes fruits are preserved in a strong syrup (strong to prevent it running into the alcoholic fermentation); sometimes the water of the syrup is evaporated, the result being a dry confect or a candy; sometimes a portion of the water of a fruit is evaporated, and then sugar added, the result being a jam when it is pretty moist, and a marmalade when it is drier; and sometimes only the juice of a fruit is preserved, and in this case the product is called a jelly. Honey is equally efficacious as sugar in these respects, but it is seldom so used. Fruits preserved by means of honey used formerly to be called confections. 6. Articles of food may also be preserved by means of pyroligneous and acetic acids. Under this head may not only be included the direct application of the acids, but also the employment of creasote and of wood smoke. The action of all these is the same, and consists in coagulating the albumen at the surface, and thereby preventing the access of air. The application of creasote to meat to protect it for a few days has

been noticed above; but if meat be dipped in it and then dried, it may be kept for a very long time without decomposing; but this process is rarely adopted in this country. The smoke of burning wood, however (which contains creasote), is very much employed to cure both meat and fish. These substances are usually first salted and then exposed to the smoke of bark or oak-wood, to which juniper, rosemary, &c., are sometimes added. Bacon hams, tongues, pieces of beef, herrings, salmon (then called kippered salmon), are extensively treated in this manner, and haddocks (then named Finnan or Findon) are preserved by wood smoke alone, without any application of salt. It is now known, that if a piece of meat or a fish be slightly smeared over with pyroligneous acid, or dipped in it for a few seconds, it is protected from putrefaction, and has the same flavour as smoked food. Common vinegar obtained from alcohol is not used for preserving any article of food derived from a mammal, but it is used to coagulate the albumen of some fish, as salmon and herrings, and of some mollusca, as oysters. The antiseptic properties of vinegar, however, are principally taken advantage of for the purpose of preserving vegetables. As vegetables contain much water, it is necessary either to use a strong vinegar, or to abstract a portion of the water of the vegetable intended to be acted upon. In practice the latter is done by adding salt to the vegetable, and pouring off the brine that is in that manner obtained. Sour krout so much used abroad, is also in part a pickle, but the cabbage of it would seem to undergo also a fermentation of its own, in which probably lactic acid is formed. 7. Articles of food may also be preserved in alcohol, which acts by coagulating the albumen; but owing to its expense it is never applied to animal food, and only on a small scale for preserving some of the finer fruits.

V.—*The Principles of Dietetics.*

The human body consists of the following elementary bodies variously combined together,—oxygen, hydrogen, nitrogen, carbon, sulphur, phosphorus, potassium, sodium, calcium, magnesium, chlorine, and iron. These are probably arranged so as to form water, albuminous proximate principles, oleaginous ones, and to a very small extent saccharine ones, all these being grouped together so as to form flesh, glands, bones, &c. All these elements must be taken into the human body in the form of food, and they must exist in the combinations that they have acquired in vegetables or in animal flesh that has been nourished on vegetables, either directly or indirectly, through the medium of a herbivorous feeding animal. But even when an adult man has taken into his stomach the amount of the above elements that he requires, either in the form of vegetable or animal nutriment, and has by means of his organs of digestion and assimilation converted them into his own oleaginous, albuminous, and other principles, these elements can only remain a part of his frame for a very limited time. After a short interval they become putrid and poisonous, and are cast off as excretions. The weight of these excretions correspond each day, in a healthy individual, exactly with the weight and the food that, under the guidance of appetite, is taken in the same period, with this exception, that a large amount of carbon in the form of wine, alcohol, fat, &c., requires to be likewise received into the system to serve as fuel, combine with oxygen, and so keep up the animal heat. In a growing person, as a child, there is required an amount of food which, besides replenishing the daily waste, will also afford material for the new structure that is daily being added to the bulk. It may be also stated, that the rapidity with which the structures are wasted and the carbon consumed, depends very much on the amount of exercise that is taken; and accordingly the daily quantity of food varies in different individuals, and in the same individuals in different circumstances.

From the structure of the teeth, and from the relative conformation of the stomach and intestines, comparative physiologists judge that man is omnivorous, and facts in his habits certainly confirm the conclusion. Many men, as the natives of Bengal and other countries, live entirely upon vegetables; and others, as the Esquimaux, altogether upon animal food, while most examples of the human species use a mixed diet of animal and vegetable matter; and the majority of people find it most convenient to obtain a portion of their supply of carbon from fermented drinks, or from drinks distilled from such. The number of people who abstain from fermented drinks, however, proves that the requisite amount of carbon may be obtained from saccharine or oleaginous compounds, the deficiency being in general, probably, made up from the latter. There appears, nevertheless, to be little doubt but that, in order to attain the full perfection of the mental and bodily faculties, an admixture of animal and vegetable articles of food is essential; and also that a portion of the carbonaceous supply should be derived from alcoholic drinks. Those who live almost entirely upon animal food become stunted in growth, and liable to ravages of scurvy, and their mental and moral faculties are blunted and sensual; those who consume only vegetables are generally inactive and listless, and incapable of either active bodily or mental labour; and independently of other objections, there is reason to fear that the offspring of those who abstain entirely from fermented drinks become in a generation or two enervated in mind and body. It is probably in this last-mentioned manner that the decadence of the different Mohammedan nations and races is to be accounted for, at least in part.

The subject of digestion will be fully treated of in another place; but it is necessary here to notice some facts connected with it that have a more immediate bearing upon dietetics. Plants, and the classes of animals living fixed to a spot, appear to be almost constantly taking in food, and have no receptacle in which to close it. The higher animals, as man, have however such, or a stomach which receives and contains the various articles of food for some time before they are assimilated. The relative capacity of this stomach varies much in the different classes of animals. In the carnivorous, who live upon food that contains little water, and is therefore concentrated, it is small; in the herbivorous, with the members of which the contrary is the case, it is very large, while in man it is midway between the two. The proximate principles of animals and plants, when taken into this stomach, are acted upon by the gastric juice there secreted, (and which juice consists of water, hydrochloric acid, and pepsine,) and are converted into a pulpy mass, chyme, from which the albuminous, oleaginous, and saccharine principles (the mixture of which is called chyle) are absorbed and poured into the blood to be expended in nourishing and warming the body. The length of time that it takes for food to be converted into chyme varies according to the kind of food taken, in different individuals, and in the same individuals at different times; for digestion, although an organic process, is nevertheless influenced by states of the nervous system. Dr Beaumont made some experiments upon a man who had an opening into his stomach from his side—the consequence of a wound. He ascertained the length of time occupied by various articles of food to become digested. The following are extracts from his table, but they only give approximative results, and it is certain that many of them did not hold good in the majority of people:—

	hr.	min.		hr.	min.
Boiled rice,......................	1	0	Boiled eggs,.....................	3	0
Boiled tripe,....................	1	0	Beefsteak,.........................	3	0
Boiled salmon trout,.........	1	30	Boiled mutton,..................	3	0
Fried do.	1	30	Roasted mutton,..............	3	15
Broiled venison,...............	1	45	Fried flounder,.................	3	30
Boiled tapioca,.................	2	0	Cheese,............................	3	30
Boiled barley,..................	2	0	Mutton soup,....................	3	30
Boiled milk,.....................	2	0	Bread,...............................	3	30
Raw eggs,........................	2	0	Broiled veal,.....................	4	0
Raw cabbage and vinegar,	2	0	Boiled fowl,......................	4	0
Boiled turkey,..................	2	25	Roasted do.,.....................	4	0
Roast do.	2	30	Boiled salt beef,...............	4	15
Roast sucking pig,...........	2	30	Boiled pork,.....................	4	30
Roast potatoes,................	2	30	Fried veal,........................	4	30
Boiled beef,.....................	2	45	Boiled cabbage,................	4	30
Raw apples,.....................	2	50	Roast pork,.......................	5	15
Raw oysters,....................	2	55			

From more satisfactory and often repeated dietetic experiments it appears certain that food is more rapidly converted into chyme when cooked than when raw, although some people appear to be able to digest fruit, salads, and raw oysters with rapidity. Salted meat appears to be longer of digestion than unsalted, and so also do pickled vegetables than fresh ones. Animal food is certainly more rapidly digested when in a state of incipient putrefaction than when subject to the contraction of tonicity. The meat of young animals takes longer to become converted into chyme than that of old of the same kind, owing to the gelatine that it contains requiring a long time to digest. The old opinion that cooked vegetables are more difficult of digestion than cooked animal substance would seem to be quite unfounded.

With regard to the intervals between meals and the times of taking food, strong statements have been made by writers upon dietetics which have perhaps no very exact foundation. Some carnivorous animals, as serpents, only require a meal once in several weeks, but carnivorous mammals seem to need a supply of food once in the 24 hours. Dogs, for example, require feeding once a-day; but it is found with regard to them, and also to hyenas, &c., kept in zoological gardens (but it must be remembered that these animals get very little real active exercise), that two meals a-day decidedly injure their health. On the other hand, graminivorous animals, as sheep, oxen, &c., eat almost incessantly. The conformation of the digestive organs of man, and his omnivorous habits, would indicate a mean between these two. But he has unquestionably a singular power of accommodating himself to circumstances with regard to the interval between his meals. It is plain that one meal a-day was and even yet is not a very uncommon regimen. But now, especially among those classes that labour principally with their minds, the principal meal or dinner is taken late in the day, and a smaller

meal or breakfast is taken immediately after rising. Members of those classes who physically labour also take at least two meals, but such often work for an hour or two before breakfasting, and appear none the worse for their procrastination. But most of the members of the first-mentioned class feel their energies and strength not entirely recruited until some food has been taken, and that if they do not breakfast immediately after dressing, they experience a sensation of lassitude and muscular debility during the whole day. If only two full meals are taken in the day, and the one immediately after rising in the morning, it seems reasonable enough to eat the latter, or dinner, in the evening. It is sometimes assumed that digestion should never stop in the human stomach, and that as breakfast is soon digested dinner should be taken in the middle of the day, but there seems to be no good reason for admitting this as a general rule. Many people, however, do feel exhausted if they do not take in the middle of the day a small lunch, and experience shows that if too much albuminous matter be not then taken into the system the habit is at any rate quite innocuous. The meal called tea, taken soon after dinner, is in fact a part of dinner. To those who dine late, suppers, beyond very slight ones, seem unnecessary, and are certainly often injurious.

There is another important alimentary law which applies to human dietetics. It is, that without a due and pretty regular allowance of fresh vegetable food, not only does the strength become impaired, but the very dangerous disease of scurvy is induced. Before the present system of agriculture was established this pestilence was endemic every spring and latter part of winter, and still later it played fearful ravages among sailors during long voyages. Since, however, there has been a supply of potatoes and other vegetables during winter on land, and since some vegetable juices have been regularly supplied to sailors, the disease has nearly vanished, and has only occurred occasionally where fresh vegetables have been for some time neglected to be consumed.

The following then may be laid down as established facts regarding the philosophy of the food of man:—1. Articles containing albuminous proximate principles must be frequently received into the system to supply the continual waste of the economy, and these may be derived from either the animal or vegetable world. A mixture of the two, although the amount of nutriment and relative digestibility be nearly equal, seems the best. 2. A large amount of food rich in carbon must be also regularly taken into the system for respiratory purposes, and this may be done by means of oleaginous animal or vegetable principles, or saccharine principles, or by means of substances derived from saccharine ones. 3. It is indispensable to take, besides, some fresh vegetables or vegetable acids. 4. Almost all articles of food are more digestible when cooked than when raw. 5. The hours of taking food and the intervals between meals are, with a moderate limit, of little consequence; and an approximation to regularity from day to day seems to be the most important matter to aim at.

FOOD, Adulterations of. It has long been known that very fraudulent, and sometimes very unwholesome, adulterations of food are extensively practised; but until lately it was not easy in all cases to pronounce decidedly on the nature of the fraud that had been committed. Now, however, by means of the microscope and the chemist's test tube, there is little difficulty in so doing, and many important disclosures have by their use been made. The proprietors of the *Lancet* employed Dr Hassall (one of the most accomplished of the microscopical observers of our day) to thoroughly investigate the subject, and his reports have appeared from time to time in that periodical. As he published the names of the different tradespeople from whom he bought spurious or adulterated articles of food, and as none of them have succeeded in disproving (and indeed very few have ventured to contradict) any of the statements, the thorough accuracy of the report may be relied upon, and the facts in this article are based upon it. Although Dr Hassall purchased the articles of food that he examined from London shopkeepers, there can be no doubt that the same adulterations will be found in the provinces. Indeed, the great adulterators are the wholesale houses, who supply indiscriminately London and country shopkeepers.

1. *Adulterations of articles of food not avowedly of a manufactured nature.*—Milk, usually supposed to be much adulterated, is comparatively little so. In towns water is generally added to it, and a portion of the cream is likewise abstracted; but chalk, gum, &c., are very rarely employed (as has often been alleged) to give the appearance of greater strength. Salted butter is frequently melted, and when in that state has water added to it. In this manner fifty per cent. of water may, it is said, be incorporated. Lard is mixed up with water, potato flour, and refuse mutton fat, and the amount of the potato starch has sometimes been known to amount to twenty per cent. Oatmeal, in London, and perhaps elsewhere, is extensively mixed with barley meal; the latter, as it contains so much more water, only selling for about half the price of the former; but wheat flour, unless it contains alum (as it perhaps does), seems quite pure. Arrowroot is adulterated to a large extent. Of 50 samples, bought from London shops, Dr Hassall found 22 to be impure; of these, 10 scarcely contained any arrowroot at all, but were made up of sago, tapioca, and potato starch; while in the others there was a considerable admixture of these cheaper articles. Raw sugar has many impurities, among which the immense number of acari with which it swarms are the most disgusting, but it is also extensively mixed with flour (apparently to make impure dark sugar appear like purer and lighter-coloured), and perhaps with other foreign ingredients. Loaf-sugar seems sufficiently pure. Tea is in a lamentable state, for it is meddled with by both the Chinese and those through whose hands it passes here. With regard to black tea, Dickson maintains that the Chinese mix with their exportations of tea to this country many millions of pounds of leaves of other plants, which they mix with genuine tea plants. In other respects, however (and even, perhaps, in this), the Chinese do not adulterate the common black teas, as Congou, Souchong, and ordinary Pekoe; but other descriptions, as scented Orange Pekoe and Caper, are, almost without an exception, impure; the former by being glazed with black-lead, and the Caper by being extensively mixed with Paddy and Lie tea (*i.e.*, an imitation of tea leaves obtained from other plants), or by not containing any tea leaves at all, but altogether other leaves sprinkled with tea dust, and made up into little masses by means of gum, and which masses are glazed with plumbago, turmeric or Prussian blue, and the whole sprinkled over with mica, &c. But imitation black teas are also entirely made up of the leaves of indigenous plants of this country, as those of sycamore and horse-chestnut, broken down, sprinkled with catechu (to communicate tannin), dried, and coated with gum. But a still more common imposition is to purchase exhausted tea leaves (which are sold at about 3d. a lb.) from hotel-keepers and the like, and attempt to imitate fresh tea by admixture with catechu, gum, sulphate of iron (to strike a dark colour with the catechu), Prussian blue, logwood, black-lead, talc, &c. Some of these adulterations—as the Prussian blue, for example—are calculated to have serious effects upon the health. Green teas are more adulterated than black ones, a really unadulterated specimen being very rarely to be met with. They are mixed in China with leaves of other plants, are subsequently glazed with gum, Prussian blue, turmeric, and various other substances, some of which are very unwholesome. Imitation green teas of British manufacture are also occasionally, perhaps even often, exposed for sale. Coffee, until the government interfered to prohibit the sale of a mixture of coffee and chicory as "coffee," almost invariably contained a large, and sometimes an amazingly large, admixture of chicory. Several contained in addition roasted corn, beans, potatoes, sometimes red ferruginous earths, and other impurities. Ground chicory itself, so much employed to secretly mix with coffee, is itself an article extremely adulterated. Nearly a half of the specimens examined were largely so, the substances employed for the purpose being roasted wheat, ground acorns, mangold-wurzel, carrots, magohany sawdust, and ferruginous earths,—the two latter for the purpose of communicating colour. Cocoa and chocolate are no better, the great majority of samples of them being largely mixed with sugar, and with potato, and other starch; but a worse adulteration is, that they also contain colouring earthy matter (usually, probably, of a ferruginous nature, but which sometimes perhaps have for ingredients red lead and vermilion, two very dangerous ingredients), and tallow and other fats seem to be sometimes mixed with them. The acknowledged substitutes for tea, coffee, and cocoa, as *Revalenta, Semola, Prince of Wales' Food*, &c., &c., are very familiar substances. Du Barry's much vaunted "Revalenta" is a mixture of pounded lentils and barley meal, and the syrup that accompanies it is treacle. Bullock's "Semola" is the gluten of wheat with a little starch; and "the Prince of Wales' Food" is potato flour.

Ground ginger is very commonly, and very largely adulterated. Dr Hassall found three-fifths of his samples to be so, the substances admixed being sago-meal, potato flour, common flour, ground rice, cayenne pepper, and mustard husks,

and these generally constituting the greater part of the bulk of the powder. Mustard—*i.e.*, ground—is almost invariably adulterated, the articles employed for the purpose being flour and turmeric, and these sometimes constitute nearly the whole of the article. Pepper is likewise very frequently mixed with linseed meal, pea meal, powdered mustard, and other substances cheaper than itself. Cayenne pepper is scarcely ever sold pure; and as the adulterations employed are bisulphuret of mercury, red lead, and other mineral colouring-matter, cayenne pepper is often a pretty active poison. In like manner, curry-powder, of which four samples out of five were found to be adulterated, frequently contains red lead, and is therefore very deleterious. Of the other spices, cinnamon and mixed spice are often impure; but pimento, mace, cloves, and turmeric, are almost always pure. Vinegar was found by Dr Hassall to vary a good deal in strength, and also in the quantity of sulphuric acid that most of it contains; many samples containing more of this than was formerly allowed when the vinegar-makers were under the control of the excise; but some specimens, and these very good vinegars, were found to contain none of it, and this is a satisfactory proof that the addition of sulphuric acid is by no means necessary to vinegar.

2. *Adulteration of articles of food avowedly of a manufactured nature.*—Although some of the above adulterations communicate poisonous properties, yet most of them are frauds merely; some of which, however, must press very severely upon the artisan, to whom a nominally cheap article is almost irresistible. But the adulterations now to be noticed are all of a deleterious nature, and probably produce an immense amount of chronic disease, and sometimes indeed speedy death. Every sample of bread—forty-nine in number—examined by Dr Hassell contained alum. Indeed the sale of "stuff" (which is a mixture of alum and salt) to the bakers is carried on on a very large scale. The object of the baker in using it is to take advantage of the affinity that it has for water, and thereby make the bread retain more water than it otherwise would, and thus give his loaves an artificial weight, and also to whiten bad and discoloured flour, and make it pass for that of superior quality. Each 4-lb. loaf contains on an average 82 grains, and a person consuming two such loaves a-week introduces into his system in that period 2 drachms and 44 grains of alum—a quantity which, as alum is a powerful astringent, must be very injurious, and which probably produces a great deal of the dyspepsia of large towns. The unnecessary quantity of salt employed by bakers is also for the purpose of retaining water amongst the bread in unnecessary abundance. The pickles sold in bottles in the shops are very bad indeed. In the first place, few of them, if we take the definition of pickle as given in the article FOOD, are pickles at all. The vegetables are greened with copper, preserved with salt and water, and packed into bottles, into which some very weak vinegar and diluted sulphuric acid are poured. Even the vegetables are not always genuine, and white cabbage is dyed to pass for red, slices of turnips made to look like cucumbers, &c. Of twenty specimens examined by Dr Hassall, the supposed vinegar never contained the proper amount of acetic acid, and in general only about half. All contained oil of vitriol, and, which is still worse, all (sixteen were tested for this purpose) salts of copper—two in small quantities only, eight in much, one in considerable, three in very considerable, one in highly deleterious, and two in immediately poisonous amount. Of the extremely injurious effects upon the health of those who daily eat these pickles thus contaminated with copper there can be no doubt. Among the symptoms produced by the continued use of cupreous preparations in small doses are paralysis, chronic inflammation of the respiratory and digestive apparatus, slow fever, and wasting of the body. The store sauces are extensively adulterated. Of twenty-eight samples of anchovy sauce, twenty-three contained Armenian bole (a ferruginous earth of a full red colour). All the samples of soy were found to consist of treacle and salt, or at least nearly so. Six out of seven bottles of tomate sauce contained colouring matter, in all cases save one Armenian bole; and a very extensively used fish-sauce contains acetate of lime and chips of charred wood. None of the sauces, however, were found to contain lead or copper. This, however, is not the case with preserves and jams, and thirty-three of these out of thirty-five that were tested were found to be adulterated with copper, and some of them in very large amount. Fruits preserved in bottles, too, nearly all had copper; and French olives in particular contained a large amount. As in preparing bottled fruits no copper utensils are employed, the poison must be deliberately added. This, too, must often be the case with preserves. Articles of sugar-confectionary are perhaps the most deleterious of all. Besides often containing sulphate of lime, which is not wholesome, the greater proportion of the colours employed are virulent poisons. Among these may be mentioned red oxide of lead, carbonate of lead, and the chromate of lead, carbonate of copper, arsenite of copper, and bisulphuret of mercury. Accordingly, from time to time, cases of virulent poisoning follow the use of these coloured articles of sugar-confectionary. (See also ADULTERATION.) (W. L. K.)

FOOLS, FEAST OF, a festival anciently celebrated on New Year's Day in churches and monasteries, particularly in France, and said to have been derived from the Saturnalia of the Romans. The extravagances and indecencies that prevailed at its celebration occasioned much scandal to the church, and various attempts were made to suppress it; but these for a long period were ineffectual, and it was not until about the fifteenth century that it began generally to fall into disuse. Many of its characteristic extravagances are still preserved in the modern carnival. (Du Tilliot, *Mémoire pour servir à l'histoire de la fête des fous.*)

FOOT. See ANATOMY, and *General Index*.

FOOT, a measure of length derived from the length of the human foot, and consisting of 12 linear inches. See MENSURATION; and for its length in different countries, see WEIGHTS and MEASURES.

FOOT, in *Prosody*, a measure consisting of certain combinations of long and short syllables. These combinations, as enumerated by the best Latin and Greek prosodians, amount in all to twenty-eight, as may be seen by the following table:

Pyrrhic	∪ ∪	Amphibrachys	∪ – ∪
Spondee	– –	Amphimacer	– ∪ –
Trochee	– ∪	Bachæus	∪ – –
Iambus	∪ –	Palimbacchæus	– – ∪
Tribrach	∪ ∪ ∪	Proceleusmaticus	∪ ∪ ∪ ∪
Molossus	– – –	Dispondæus	– – – –
Dactyl	– ∪ ∪	Ditrochæus	– ∪ – ∪
Anapæst	∪ ∪ –	Diiambus	∪ – ∪ –
Choriambus	– ∪ ∪ –	Pæon tertius	∪ ∪ – ∪
Antispastus	∪ – – ∪	Pæon quartus	∪ ∪ ∪ –
Ionicus a majore	– – ∪ ∪	Epitritus primus	∪ – – –
Ionicus a minore	∪ ∪ – –	Epitritus secundus	– ∪ – –
Pæon primus	– ∪ ∪ ∪	Epitritus tertius	– – ∪ –
Pæon secundus	∪ – ∪ ∪	Epitritus quartus	– – – ∪

By rejecting such of those feet as are merely compounds or reduplications, the number of simple feet is reduced to twelve.

FOOTE, SAMUEL, a celebrated English humourist and actor of the eighteenth century, was born of a good family at Truro, in Cornwall, in 1720. He was educated at the collegiate school of Worcester, and in his seventeenth year elected scholar of Worcester College, Oxford. During his academic career his powers of mimicry and humour began to show themselves, and were exercised with such success and indiscretion against some of the University dons, that Foote found it convenient to leave college in 1740, "without having incurred, however, any public censure." He carried away with him a very respectable amount of classical learning, and entered himself of the Temple as a student of law. But the pleasures of the town had greater attractions for him than Coke upon Lyttleton, and in a short time he had lost a handsome patrimony at the gambling-table. It is generally stated that about this time Foote married; but no traces of any such settled connection are discoverable in his career. He had two sons, indeed, but they were not born in lawful wedlock, and he used wittily to excuse his bachelorhood by saying, that "you

must count a lady's age as you do a hand at picquet, twenty-five, twenty-six, twenty-seven, twenty-eight, twenty-nine—*sixty*, and he had no ambition to awake one morning and find himself so unequally matched for the whole length of a life." Driven to the stage for support, he made his *début* in the character of Othello; but finding tragedy ill-suited to his powers, he renounced it and betook himself to comedy, in which, however, he only played with mediocre success, till he began to parts of his own writing. In 1747 he became manager of the Haymarket theatre, and succeeded in drawing large crowds by his admirable mimicry of all the social and political notabilities of the day. He kept his theatre open for many years without a patent; but he procured one at length through the influence of the Duke of York in the following manner. Riding out one day in company with that nobleman, he was thrown from his horse, and received injuries which necessitated the amputation of his leg. The Duke of York procured for him the long-withheld patent by way of compensation for the accident. The loss of his limb did not force him immediately to quit the stage, but it undermined his constitution so much that he disposed of his patent to the elder Colman, and only acted when it suited his humour. His death is said to have been accelerated by the shock he received from being obliged to stand a public trial in consequence of an infamous charge brought against him by an old servant of his own, suborned by the notorious Duchess of Kingston, whose enmity Foote had incurred by delineating her character and detailing her history in one of his comedies. In October 1777 he set out for France with the hope of there recovering his health, but death arrested his progress at Dover. He was buried in Westminster Abbey, where no memorial has yet been erected in his honour. Common consent has awarded to Foote the title of the English Aristophanes. In some respects the epithet is happy enough; in others it is little short of ridiculous. It was said of the Greek comedian that he wielded a censorship more formidable than that of the archons; it is equally true of the Englishman, that he exercised a wider jurisdiction than any chief-justice of his day. There was also a strong resemblance between the two satirists in point of wit, ready and abundant flow of humour, keen sarcasm, and above all in the audacity with which both employed their powers in bringing down laughter and scorn upon the living vices and hypocrisies of their respective eras. But Aristophanes, had he chosen to devote himself to tragedy, would have attained to as high eminence in that field as he has done in comedy. In this he shows to great advantage beside Foote, who, with comic powers as great, had neither the imagination nor the wealth of poetry of the Greek. Few of Foote's pieces are now produced on the stage. The very qualities which made him so formidable in his own day have contributed more than anything else to ensure his being forgotten in ours. His comedies, though containing admirable delineations of character, were generally *pièces d'occasion*, and are consequently devoid of that wide and general human interest which secures the immortality of an author. The whims, humours, caprices, and even persons of his own day were the subjects to which Foote was most partial. His plays are now more valuable in an historical than a dramatic point of view, and are now read chiefly by those who desire to know the spirit of social life in London during the latter half of last century.

Foote's most important plays are "*The Minor*," levelled chiefly against the Methodists; "*The Englishman returned from Paris*," which satirizes the mania for travelling. The bar is lashed in "*The Lame Lover*;" debating societies in "*The Orators*;" and newspapers in "*The Bankrupt*." Those of his pieces which kept the stage longest were "*The Liar*" and "*The Mayor of Garrat*," the humour of which is less individual than in most of his other plays. Altogether Foote is likely to be remembered by posterity rather as a social figure than as a writer or actor. As a converser he is admitted to have had almost no superior in his own day in England, except Johnson. His *bon-mots* are scarcely inferior to any in the English tongue. The personal character of Foote was in many respects very amiable. He dissipated three fortunes, of which he inherited the first and made the other two, but his heart remained as open to noble influences at the end of his career as at the beginning. He was utterly devoid of jealousy, the besetting sin of his craft; and countless instances are recorded of his generosity to obscure but meritorious actors. His friend Jewel erected a monument to his memory in Dover where he died, and inscribed on it nothing about his genius or his humour, his acting or his writing, but merely that "he had a hand as open as day to melting charity." (See *Quarterly Review*, vol. xcv., p. 483.)

FORAGE, in *Military affairs*, denotes food of any kind brought into the camp for the sustenance of the horses, &c.

FORBES, Duncan, of Culloden, one of the most honest and enlightened of Scottish patriots, was descended from the Forbeses of Tolquhoun in Aberdeenshire, a branch of whom had settled in Inverness about the end of the sixteenth century. His great-grandfather, the first northern Duncan Forbes, carried on business in the Highland capital, exchanging the native products of the country (chiefly salmon and the skins of game and cattle collected from every strath and glen) for the conveniences and luxuries to be had in England and Holland. He built ships, traded largely, and was able in 1625 to purchase the barony of Culloden from the laird of Mackintosh. He was also provost of the town, and in this capacity it fell to the lot of "Grey Duncan" (as from his flowing grey beard he was usually called) to receive the Marquis of Montrose, a prisoner, on his way from the north to Edinburgh, where shortly afterwards he was tried and beheaded. Forbes was a stern old Whig, but it appears he did not, like some others of higher rank, insult the fallen general in his misfortunes. He spread a table at the market cross, in the street through which Montrose had to pass, and covered it with wines and other refreshments, of which the prisoner partook. He accompanied him to the end of the town, and on taking leave of him courteously said, "My lord, I am sorry for your circumstances." Montrose replied, "I am sorry for being the object of your pity." (*MS. History of the Frasers.*) The incident has a touch of the picturesque romance of the old feudal times. The son and successor of Grey Duncan continued the prosperity of the family, and added to its possessions the barony of Ferrintosh in Ross-shire, and the estate of Bunchrew, a pleasant well-wooded spot on the southern shore of the Moray Frith, about three miles from Inverness. Both of these properties were purchased from the Frasers of Lovat, on whose more ancient greatness the Forbeses were now encroaching. A second Duncan Forbes inherited the strong Presbyterian Whig principles, as well as the lands of his progenitors, and was a conspicuous member of the Convention Parliament. As such, in 1689, his estates were ravaged and wasted by the Jacobite soldiery under Buchan and Cannon, and to compensate him for his losses, the Scottish Parliament granted him a privilege, always dear in the Highlands—a license perpetual to him and his heirs to distil *duty free* all the barley that might be grown in Ferrintosh. The "loyal Forbes' chartered boast," as Burns designates it, became a valuable possession. It was enjoyed nearly a century, and was withdrawn by the government in 1785, when a sum of about L.20,000 was granted as compensation. The third Duncan Forbes, afterwards Lord President, was born at Bunchrew or Culloden in the year 1685. He studied law at Edinburgh and Leyden, and was admitted advocate at the Scottish bar in 1709. His own talents, and the influence of the Argyle family, soon elevated him in his profession. At the period of the rebellion in 1715, he stood firm to the

Hanoverian cause, as did also his brother, John Forbes, then Laird of Culloden, a popular and hospitable Highland gentleman, whose convivialities are described in Burt's *Letters from the North of Scotland.* In 1722 Duncan Forbes was returned member for Inverness, and in 1725 he was appointed Lord Advocate. He succeeded to the patrimonial estates in 1734, and in 1737 he attained to the highest legal honours in Scotland, being made Lord President of the Court of Session. As Lord Advocate, Forbes had laboured to improve the legislation and revenue of the country, to spread manufactures and extend trade, and no less to render the imperial government popular and respected in Scotland. In the proceedings which followed tne memorable Porteous mob, when the government brought in a bill (which passed the Lords) for disgracing and removing the Lord Provost of Edinburgh, and for abolishing the town-guard and city gate, Forbes opposed the measure, and both spoke and voted against that paltry and vindictive outrage on the national feeling. A miserable spirit of faction and jealousy pervaded the ministry as to all just and public claims, especially on Scottish questions, while at the same time they were profuse and profligate on private and party objects. Forbes' influence abated if it could not remove this evil, and as Lord President he also carried out some legal reforms and insured the quick and impartial administration of the law. The Rebellion of 1745 found him at his post, and it tried all his patriotism. He had in vain urged upon the government the expediency of embodying Highland regiments, putting them under the command of colonels whose loyalty could be relied upon, but officering them with the native chieftains and cadets of old families in the north. Such a plan was afterwards successfully pursued by Chatham; but though Walpole is said to have approved of Forbes's scheme, the Council unanimously rejected it. Had it been adopted in time, and a few thousand pounds placed in Forbes's hands to be spent usefully in the Highlands, there would have been no Jacobite rising in '45. Through his personal influence with the chiefs of Macdonald and Macleod, those two powerful western clans were prevented from taking the field for Charles Edward; the town of Inverness he also kept loyal and well protected at the commencement of the struggle, and many of the neighbouring proprietors were won over by his persuasions. His correspondence with Lord Lovat, published in the Culloden Papers, affords a fine illustration of his character, in which the firmness of loyal principle and duty is found blended with neighbourly kindness and consideration. In the case of Lovat he had to contend with inveterate duplicity and low-minded ambition. The crafty old chief had been nearly all his life a plotter for the restoration of the Stuarts, but he would never have raised his clan had he not obtained from the Court of St Germains a commission as lieutenant-general and a patent of dukedom. This gratified his inordinate vanity and love of power. The ducal coronet, surmounting his yew-crested bonnet as chief of the Frasers, formed a vision of greatness unparalleled in the north! At this critical juncture of affairs, the apathy of the government was immovable. No advance of arms or money could be obtained until it was too late, and though Forbes employed all his own means and what money he could borrow on his personal security, his resources were quite inadequate to the emergency. And it is doubtful whether these advances were ever fully repaid. Part was doled out to him, after repeated solicitations, that his credit might be maintained in the country—his own sacrifices he did not mention, but he had fallen into disgrace in consequence of his exertions to mitigate the inhuman and impolitic severities inflicted upon the poor misguided Highlanders after their defeat at Culloden. His entreaties for mercy were heard with contempt—a brigade, it was said, would give laws! The ingratitude of the government, and the many distressing circumstances connected with this insurrection, sunk deep into the mind of Forbes. He never fairly rallied from his depression, his health declined, and he died on the 10th of December 1747, in the sixty-second year of his age. A tardy act of justice was rendered to his family. Two years after his death, a pension of L.400 per annum was granted to his only son, John Forbes; and the same good fortune that had attended the early history of his race, enabled this worthy man (the chosen associate of Thomson the poet in his youth) to free the estate from the debt so generously contracted by his father, and to add to the amount of his possessions by the purchase of contiguous lands. The fair fame of the President is, however, the proudest inheritance of his descendants. He was a patriot without ostentation or pretence—a true Scotsman with no narrow prejudices—an accomplished and even erudite scholar without pedantry—a man of genuine piety without asceticism or intolerance. His country long felt his influence through her reviving arts and institutions, and the example of such a character in that coarse and venal age, and among a people distracted by faction, political strife, and national antipathies, while it was invaluable to his contemporaries in a man of high position, is entitled to the lasting gratitude and veneration of his countrymen. In his intervals of leisure, President Forbes cultivated the study of Hebrew and biblical criticism. He was something of a speculative theologian, having embraced the views of his friend John Hutchison, the English philosopher and theological writer, that a system of natural science as well as religion could be drawn from the books of the Old Testament if interpreted according to the radical import or root of the language. In his retirement at Bunchrew—his favourite retreat—he is said to have read the Hebrew bible through eight times. His published writings are—1, A Letter to a Bishop, concerning some Important Discoveries in Philosophy and Theology; 2, Some Thoughts concerning Religion, natural and revealed, &c.; and 3, Reflections on Incredulity. His correspondence was collected and published in 1815, and a Memoir of him (from the family papers) was written by John Hill Burton, Esq., advocate, and published along with a Life of Lord Lovat, in 1847. (R. C—S.)

FORBES, EDWARD, F.R.S., F.G.S., &c., Professor of Natural History in the University of Edinburgh, was a distinguished naturalist. His range of subjects was extensive, while his consistent conduct, the candour of his disposition, the cheerfulness and amenity of his mind and manners, all added to the influence produced by the possession of great natural powers, assiduously and successfully devoted to the attainment of knowledge. So early was his admiration of natural objects developed, that he has been heard to say, that had he attempted to define the period when the love of natural history first arose as the day-star in his heart, he must have searched back into the dim and distant recollections of his earliest childhood. At this period, also, he compiled, for private use, a Manual of British Natural History, in all its branches,—a youthful labour to which he often afterwards referred with advantage.

At the age of sixteen he visited London, and while there occupied himself chiefly in the acquirement of the art of drawing, under Sass, a well-known trainer for the Royal Academy in those days. The careful practice of drawing in outline from the antique afterwards proved of great advantage to him in all his pursuits and publications. He proceeded in 1831 to Edinburgh, where he entered the medical classes. Although the study of medicine was the ostensible object of his matriculation, it was foreseen that the practice of that profession would have but few charms for one whose mind was so pervaded by the love of nature; and he in truth soon devoted himself almost entirely to the study of natural history. He became at once the friend and pupil Jameson, of whom he eventually became the successor;

and he also derived great advantage from his acquaintance with Professor Graham, whom he delighted to accompany in his botanical explorations in the Highlands of Scotland. During this youthful and energetic period, scarcely a season elapsed without some important excursion in connection with botany, or the dredging of the great waters. At the age of eighteen, with the companionship of a fellow-student, he visited Norway, from which he returned with large collections. His first public contribution to science was now made under the title of "Notes of a Natural History Tour in Norway," in the 8th and 9th volumes of Loudon's Magazine. At nearly the same period, and in the same work, he printed his earliest papers on submarine researches, "Records of the result of Dredging," a department in which he eventually became so noted.

He thus pursued his studies with great intensity of thought, yet with such radiant cheerfulness and buoyancy of spirit, as possibly to induce the belief, among those who saw not beneath the surface, that he was making less progress than others of less impulsive habit who kept upon the shady side of science. Neither did he confine himself to purely scientific matters, but mingled with these many miscellaneous exercises of a literary nature; thus strengthening and enlarging his intellectual faculties, and fitting himself all the more to take advantage of those points in the minds of younger men of the same kindly constitution, to whom a discursive power and some imaginative impulse are required to create and carry onwards their scientific tendencies. But though bold and adventurous, he was by no means fanciful. If it was by the exercise of something akin to the imaginative faculty that he foresaw and felt the grandeur of those general views, such as the graduated zones of living life, which exist not alone upon the sunny surface of the earth, but in the darksome waters far beneath it, which he was among the first to announce, it was by the most patient and oft-repeated investigations that he ascertained and combined the facts on which his final views were founded. The important law, of which he was among the earliest, as he afterwards became the most successful, exponent, is this,—that as there are great and characteristically distinct zones of animal and vegetable life *in height*, as we proceed upwards on the sides of mountains, or into alpine valleys, from the sea shore, so there are also equally distinct and different zones of animal and vegetable life *in depth*, as we proceed from that shore down the sides of sea-encircled mountains and into the great submerged and sunless valleys of the ocean.

Forbes continued to make Edinburgh his headquarters almost uninterruptedly till 1839; though he spent the greater part of 1837 in Paris, studying geology under Constant Prevost, mineralogy under Beudant, and zoology under De Blainville and Geoffroy St Hilaire. During the autumn of these several years he explored some interesting portions of Continental Europe, or beyond it, doing good service to science by a somewhat lengthened sojourn at one time in Illyria, at another in Algiers. In 1838 he visited Styria and Carniola, and published some observations on those countries in the "Proceedings of the Botanical Society," as he afterwards did an account of the fresh-water shells of Algiers and Bougia, in the "Annals of Natural History" for 1839. About the same period he published a short treatise on the mollusca of the Irish Sea, and several papers in zoology and botany.[1] In the winter of 1839 he also delivered two courses of lectures on zoology and comparative anatomy—one strictly scientific—the other of a more popular nature.

In 1841 he published his beautiful and well-known work, the "History of British Star Fishes and other Echinoderms," adorned by not fewer than 120 illustrations, all designed by himself. It may be here stated that his great artistic skill was fully and frequently employed, not only in the accurate representation of the precise forms of animal life, but also in sketches of rural and architectural scenery, and most characteristically of all in the vignettes and tail-pieces to his various works, where we have humour and sentiment very gracefully combined. In the spring of 1854 he accepted an invitation from his friend Captain Graves to join the surveying ship Beacon, then employed on the coast of Asia Minor and the adjacent islands; and having obtained a nominal appointment from the Admiralty, he joined that vessel in the capacity of naturalist. During 1841, and the following year, he pursued his researches with continuous and unabated energy, assisted by Captain Graves, who omitted no opportunity of enabling his scientific companion to accomplish all in his power. What marvel, then, that in the course of almost countless excursions with the Beacon and her boats, along the coasts of Asia Minor, and among the islands of the Ægean Sea, so rich a harvest should have been reaped. The results of their researches were made known to the public in the "Report on the Mollusca and Radiata of the Ægean Sea, and on their distribution, considered as bearing on Geology," read to the meeting of the British Association held at Cork in 1843. It appears that the data on which that report is founded were derived from eighteen months' constant researches. The calculations were based on very numerous and fully recorded dredging operations at various depths, from 1 to 130 fathoms, and in many localities from the shores of the Morea to those of Asia Minor—the chief objects being to give account of the distribution of the several tribes of mollusca and radiata in the Eastern Mediterranean, to exhibit their range in depth, and the circumstances under which they are found, to inquire into the laws which appear to regulate their distribution, and to show the general bearings of these investigations on the science of geology.

The most important result of these inquiries was the ascertainment of the almost uniform occurrence of particular species in particular zones of depth below the surface. This distribution of marine life is determined by three primary, modified by several secondary, influences. The primary influences are—climate, sea composition, and depth—the most important of the secondary agencies being the character and constitution of the sea-bottom—for according as rock, mud, sand, gravelly or weedy ground prevails, so will the number of the several genera and species vary. The form and geological construction of the neighbouring coast are also modifying features, and considerable influence is exercised by the run of tides and currents, and the influx of fresh water. The elements to be considered are therefore of a somewhat complicated nature.

Forbes gives us in this report an ample description of eight well-marked regions of depth in these eastern waters, each characterized by its own peculiar fauna, and, in such places as produce plants, by its flora. These regions are distinguished from each other by the association of the species they severally include. Certain species occur in no other, several are found in one region which do not range into the next above, whilst yet they extend to that below, or *vice versâ;* certain species have their maximum of development in each zone, being most prolific in individuals in that zone in which is their maximum, and of which they may be regarded as specially characteristic, Every zone has also a more or less mineral character, the sea-bottom not being equally variable in each, and becoming more and more uniform as we descend. The deeper zones, too, are the greater in extent, so that whilst the first or most superficial is but 12, the eighth or lowest is above

[1] For a nearly complete list of Professor Edward Forbes' writings, see *Bibliographia Zoologiæ et Geologiæ*, vol. ii., pp. 445–450.

700 feet in perpendicular range—its horizontal extent increasing in a somewhat similar proportion. Another marked and significant feature is, that as we attain to the eighth zone, the number of species, and of individuals, diminishes as we descend—thus pointing to a zero in the distribution of animal life, as yet unvisited. Species disappear in depth, which do not seem to be replaced by others; and from various observations the inference has been deduced, that the extent of the range of a species in depth is correspondent with its geographical distribution. These eight regions are themselves the scene of incessant change, for not only are the depths modified by the addition of fresh matter, but the very animals themselves, by their own increase, so alter the nature of the sea-bottom as to render it unfit for their own existence, until a new layer of sedimentary matter, uncharged with living organic contents, has formed a fresh soil for similar or other animals to thrive on. Of these observations, the high importance is obvious as explaining so many of the constantly recurring phenomena now brought under the notice of the geologist, such, for example, as the interstratification of fossiliferous and non-fossiliferous beds. The report refers to the phenomena which would be presented to us were the bottom of the Ægean Sea to be elevated and converted into dry land, or to be filled up by a long serious of sedimentary deposits, and concludes by stating that, " supposing such an elevation to have taken place, a knowledge of the association of species in the regions of depth would enable us to form a pretty accurate notion of the depth of water in which each bed was deposited. A beautiful example is given from observations made on the island of Santorin, and under different circumstances the contrary observations might be made; the geologist is thus enabled, by a careful examination of the successive overlying groups of species, to ascertain whether, in any given locality brought under his notice, the sea-bottom was being elevated or depressed."

The Beacon having visited the coasts of Lycia in the beginning of 1842, for the purpose of carrying off the remarkable remains of antiquity discovered at Xanthus by Sir Charles Fellows, her crew were employed there in making excavations among the ruins, and preparing for the removal of the marbles. For the latter task, however, the vessel proved unfitted, and while she was sent back to Malta for the necessary requirements, Forbes and Lieutenant Spratt (having been previously joined by the Rev. Mr Daniel, an accomplished draughtsman) were permitted to remain, for the sake of further antiquarian, as well as natural history, investigations. On one occasion, in company with Mr Hoskyn, the party discovered the sites of two of the Cibyratic cities; and a second excursion was still more important, as they determined the precise position of not less than eighteen ancient cities, till then unknown to geographers,—the names of fifteen being identified by inscriptions found among the ruins. During this expedition, Mr Daniel unfortunately fell a victim to the malignant malaria of the country, and Forbes himself narrowly escaped. However, he so entirely recovered as to have been on the point of setting out to prosecute his dredging operations in Egypt and the Red Sea, when the information reached him that he had been appointed to the chair of Botany in King's College, London, vacant by the death of David Don. He returned immediately to England, and delivered his inaugural lecture May 8, 1843.

A short time prior to this, Forbes had become closely connected with another important institution. On the close of 1842, Mr Londsdale, the valued curator of the museum of the geological society, resigned that situation, and Forbes was appointed in his room. But before the close of 1843, his abilities as a palæontologist introduced him into a more extended sphere of action. On the establishment of the museum of practical geology, in connection with the ordnance geological survey, under the direction of Sir Henry De la Beche, Forbes was appointed palæontologist to that new institution. On the removal of the museum to Jermyn Street, he was named its professor of natural history; and here his talents had ample scope for exercise.

Towards the conclusion of 1846 he published, in conjunction with Lieutenant (afterwards Captain) Spratt, " Travels in Lycia, Milyas, and the Cibyrates," an admirable work. About this period he gave forth also a most important contribution to geology and the sciences to which it is related, " On the connection between the Distribution of the existing Fauna and Flora of the British Isles, and the geological changes which have affected their area." In this work we have opened up to us a wide field of speculative research into almost every department of natural science, while it contains, imbedded in itself, a large and varied mass of knowledge. It throws great light on some difficult and complex inquiries regarding the age and relationship of the rocks of Britain. It affords an admirable example of the aid to be derived from other branches of natural history in the prosecution of geological researches, and of the application of animal and vegetable physiology, and a knowledge of the habits and distribution of animals and plants, in the elucidation of very difficult problems in geology. The principle or theory of this essay is based on the presumed existence of *specific centres*, or certain geographical points from which the individuals of each species have been diffused, involving their consequent descent from a single progenitor or pair, according as the sexes are united or distinct. The author is of opinion that the abandonment of that doctrine would place in a very dubious position all evidence the palæontologist could offer to the geologist towards the comparison and identification of strata, and the determination of the epoch of their formation. Having thus assumed the truth of the doctrine of specific centres, he then proposes to solve the problem of the origin of those assemblages of animals and plants which now inhabit the British Islands. Within even that limited area naturalists have recently shown that there are numerous animals and plants which are by no means universally distributed, but are congregated in such a way as to form distinct groups or provinces of life. Our vegetation, for example, exhibits five well-marked Floras, four of which are restricted to definite districts, whilst the fifth, besides exclusively claiming a portion of the area, also commingles with and overspreads the others. Forbes was of opinion, that of the three modes by which an isolated area may become inhabited by animals and plants, immigration before isolation of the area was that by which the British Isles have chiefly acquired their existing fauna and flora, terrestrial as well as marine, and that it took place subsequently to the miocene epoch. From this argument it follows, that previous to the isolation of our area, it must have been in direct union with those portions of the European continent the floras of which are shown to be identical with one or other of the five floras of the British Isles. These five distinct floras, and the districts with which he maintains they demonstrate our former connection, are as follows:—

1. *The West Irish Flora.* The high lands in the north of Spain present the nearest point where a vegetation occurs identical with that which is characteristic of the mountainous district of the west and south-west of Ireland; consequently, at some period or other, continuous dry land must have existed from the coast of Spain to that of Ireland. 2. *The Devon Flora,*—connected with that of the Channel Islands, and the neighbouring parts of France. 3. *The Kentish Flora.* The vegetation of the south-east of England is distinguished by the presence of a number of species common to this district and the opposite coast of France. 4. *The Alpine Flora.* On the tops of some of our most lofty mountains, particularly in Scotland, are

plants not found elsewhere in the British islands, but which are identical with those of the Scandinavian Alps, thus pointing to a former connection in that direction. 5. *The General Flora.* This universal flora is almost identical as to species with the flora of central and western Europe, and may properly be styled Germanic.

The distribution of marine species, both of animals and plants, is also very skilfully handled. That of the British mollusca, a favourite department, is gone into *con amore*, and a mass of information presented of great value, and at that time elsewhere unattainable. It is of great importance to the student of the tertiary geology. The author's conclusions are: That the flora and fauna, terrestrial and marine, of the British islands and seas have originated, so far as that area is concerned, since the miocene epoch: That the greater part of the terrestrial animals and flowering plants now inhabiting the British islands are members of specific centres beyond their area, and have migrated to it over continuous land, before, during, or after the glacial epoch: That all the changes, before, during, or after that epoch appear to have been gradual and not sudden, so that no marked line of demarcation can be drawn between the creatures inhabiting the same element and the same locality during two proximate periods.

For many successive seasons after this time, Forbes laboured with great assiduity, not only with pen and pencil, but in the arrangement and classification of the vast store of fossils collected by the ordnance geological surveyors, and placed in the Jermyn Street Museum. In connection with this department may here be mentioned the palæontological and geological map of the British islands, with explanatory dissertation, and the map of the "Distribution of Marine Life." In 1853 he was elected president of the Geological Society, and had scarcely occupied that chair for half the allotted time when the death of his old master, Jameson, opened up to him the professorship of natural history in the University of Edinburgh.

Professor Forbes delivered a course of lectures in Edinburgh during the summer session of 1854. He had commenced his more extended winter course when he was seized with an internal ailment from which he had previously suffered. The symptoms soon became alarming, his strength sunk rapidly, and he died, after not many days' illness, at Wardie, near Edinburgh, on the evening of Saturday, Nov. 18, 1854, in the fortieth year of his age, leaving a widow, with two infants, a son and a daughter. He was buried in the Dean Cemetery.[1] (J. W.)

FORBES, *John*, one of the most learned divines that Scotland has produced, was born May 2, 1593. He was the descendant of an ancient and opulent family: his father was Patrick Forbes, bishop of Aberdeen, his mother was Lucretia the daughter of David Spence of Wormiston. His paternal ancestor was a younger son of Lord Forbes, and he was thus connected with some of the principal families in his native district.

John Forbes, who was the second son of Patrick Forbes, after having studied at Aberdeen, was sent to the university of Heidelberg. He likewise prosecuted his studies at Sedan, and in other universities. Having devoted much time and labour to the acquisition of Greek and Hebrew, he returned to his native country in 1619, being then in the twenty-sixth year of his age, and on the 27th of April he was admitted professor of divinity in King's College, Aberdeen, where he laboured with great diligence, and acquired the character of an able and useful teacher. He was skilled in ecclesiastical antiquity; and, not content with delivering what is called a system of divinity, he exhibited a very elaborate deduction of the progress of Christian doctrine in various ages of the church. Of the value of his instructions in this department, a very adequate opinion may be formed from the perusal of a work which he published in the maturity of his learning and judgment. Nor did he neglect to instruct his students in practical religion: one division of his lectures related to moral theology, another to the pastoral care and to residence.

While he was engaged in these useful and honourable labours, the kingdom was agitated by religious dissensions. Episcopacy, commonly described by the more odious name of prelacy, was no favourite with the great body of the people; and the five articles of Perth, passed in 1618, and relating to kneeling at the communion, the observance of festivals, confirmation, private baptism, and private communion, had excited a violence of opposition with which it was found very difficult to contend. Dr Forbes, who was as much distinguished by his piety as by his learning, endeavoured to promote peaceable measures; and with this view, he published his earliest work, bearing the title of *Irenicum Amatoribus Veritatis et Pacis in Ecclesia Scoticana.*" Aberdoniæ, 1629, 4to. Of this work he sent a copy to Archbishop Usher, who received it with much cordiality. The bishop of Aberdeen did not live to witness the subversion of episcopacy: he died on the 28th of March 1635, in the seventy-first year of his age. This prelate being regarded as the restorer of the university, and as a great pillar of the church, his death was sincerely lamented by the adherents of his own party. As his eldest son had died ten years before, the professor of divinity succeeded to the family estates. Soon after the bishop's decease, a volume of 429 pages, and including a portrait, was published under the following title:—"*Funerals of a Right Reverend Father in God, Patrick Forbes of Corse, Bishop of Aberdeen.* Τοῦ ἐν ἁγίοις Reverendissimi in Christo Patris, Patricii Forbesii a Corse, Episcopi Abredoniensis, Tumulus, a multis omnium ordinum collachrymantibus variegato opere exornatus." Aberdene, 1635, 4to.

Dr Forbes, who was naturally disposed to think that nothing is better than peace,[2] next published "A peaceable Warning to the Subjects in Scotland; given in the yeare of God 1638." Aberdene, 4to. It was speedily answered in a tract ascribed to Calderwood, the most strenuous defender of the Presbyterian cause. Dr Forbes was treated with some degree of tenderness; and the Covenanters being solicitous to gain such a convert, the proceedings against him in the ecclesiastical courts were protracted for several years. After some preliminary steps, he was in 1640 cited to appear at Aberdeen before a delegation of the general assembly. He was declared to be free from the taint of popery and Arminianism; but as he still adhered to episcopacy, and declined to subscribe the covenant, his case, through the influence of Baillie, was remitted to the presbytery of Edinburgh. He was allowed a month to yield satisfaction to this judicatory, and as he failed to do so, sentence of deprivation was pronounced against him. In 1643 he moved the synod of Aberdeen to make application to the general assembly, that he might be permitted to retain his professorship without subscription; but it was there determined that his deprivation was valid from the beginning. He had purchased two houses adjoining to the college, and had assigned one of them to the professor of divinity, and the other to the *cantor*, a person on the foundation. In the deed of conveyance, he neglected to reserve to himself a liferent in the professor's house; nor can it be mentioned

[1] Professor Edward Forbes's life and labours, and lamented death, were faithfully and feelingly recorded in most of our literary and scientific journals, and in many newspapers of the day. We have made the preceding brief memoir to conform chiefly with a notice in No. 1 (for January 1855) of the *New Series* of the *Edinburgh New Philosophical Journal*, and have availed ourselves, in our geological abstracts, of some observations by W. J. Hamilton, Esq., President of the Geological Society, contained in his anniversary address. See *Quarterly Journal of the Geological Society*, May 1855.

[2] Οὐδέν ἐστιν ἄμεινον εἰρήνης. (S. Ignatii Epistolæ genuinæ, p. 17, edit. Smith.)

Forbes.

without regret and indignation that he was obliged to resign it to his successor in office.

He was anxious to continue his residence in the university, for the benefit of prosecuting his researches in the public libraries; but he found that he must either subscribe the solemn league and covenant, or abandon his native country. Preferring the latter alternative, he embarked for Holland on the 5th of April 1644, and, after a voyage of five days, landed at Campvere. He travelled through the different provinces, and frequently preached in the Scottish and English churches. He had formerly married a lady of Middelburg, named Soete Roos-boom, who died on the 19th of January 1640. She was the mother of nine children; but only one of them, a son named George, was alive at the time of the father's exile. Dr Forbes resided chiefly at Amsterdam, and occupied himself in preparing for the press a work of great research and value. It appeared under the title of "*Instructiones Historico-Theologicæ de Doctrinæ Christiana, et vario Rerum Statu, ortisque Erroribus et Controversiis, jam inde a temporibus Apostolicis ad tempora usque seculi decimi-septimi priora.*" Amst. 1645, fol. A second edition followed after a considerable interval. Genevæ, 1680, fol. And an abridgment of the work was published by Arnoldus Montanus, under the title of *Forbesius contractus*. Amst. 1663, 8vo. Forbes was enabled to prefix to his ample volume the favourable judgment of the theological faculties of Leyden, Utrecht, and Franeker, as well as that of Rivet, Maresius, and Vossius. This book established the reputation of the author as a theologian of a very high rank. Bishop Burnet speaks of it as "a work which, if he had finished it, and had been suffered to enjoy the privacies of his retirement and study, to give us the second volume, had been the greatest treasure of theological learning that perhaps the world has yet seen."[1] Dr Cave has likewise mentioned it as a work of great value,[2] and it has received similar commendation from writers of many different nations.

After having resided upwards of two years in Holland, Forbes embarked at Campvere on the 8th, and arrived at Aberdeen on the 14th of July 1646. He immediately retired to his country-seat at Corse, and was permitted to spend the remainder of his days in learned and devout seclusion. He died on the 29th of April 1648, having completed the fifty-fifth year of his age. A short time before his death, he made application to the presbytery for permission to have his bones deposited in Bishop Dunbar's aisle in the cathedral church, beside those of his father and wife; but even this last favour was denied to a learned and excellent man, whose fault was a difference of opinion on the subject, not of Christian doctrine, but of ecclesiastical polity. He then directed his body to be interred in the churchyard of Leochel, where no monument was erected to his memory.[3] He left an only son, who is described by Dr Garden as the heir of his father's estates, but not of his virtues.

Dr Forbes was small in stature, and of a somewhat swarthy complexion; and, with respect to his habits of study, we are informed that he always read and wrote in a standing posture. One of the few relaxations in which he indulged was the game of golf. His conduct was upright and consistent in times of no small difficulty and distress.

An honourable monument was at length erected to his memory, in a collective edition of his Latin works. "*Reverendi viri Johannis Forbésii a Corse, Presbyteri et SS. Theologiæ Doctoris, ejusdemque Professoris in Academia Aberdonensi, Opera omnia, inter quæ plurima posthuma, reliqua ab ipso auctore interpolata, emendata atque aucta.*" Amstelædami, 1703, 2 tom. fol. The second volume bears the date of 1702. The edition is introduced by two dedications written by George Garden, D.D., an advertisement by Wetstein the printer, and a preface by Dr Gürtler, professor of divinity at Deventer. A copious life of the author, by Dr Garden, is next subjoined. Under the title of "*J. Forbesii Vita interior*," he has had added an abstract of Forbes's diary, which was written in English. One of the posthumous works is an ample treatise, entitled "*Theologiæ Moralis libri decem; in quibus Præcepta Decalogi exponuntur, et variæ circa Dei Legem, et specialia ejusdem Præcepta, Controversiæ dissolvuntur, et Casus Conscientiæ explicantur.*"

Forbes.

Forbes, *William*, bishop of Edinburgh, born at Aberdeen in the year 1585, was the son of Thomas Forbes, a respectable citizen descended from Forbes of Corsinday, whose ancestor was the second son of the same Lord Forbes from whom Forbes of Corse derived his lineage. His mother was Janet the sister of Dr Cargill, an eminent physician. From the grammar-school, where he had made unusual progress, he was at the early age of twelve removed to Mariscbal College, and there took the degree of A.M. The principal, Gilbert Gray, was so much pleased with his scholarship and modesty, that he procured his appointment to the professorship of logic. It was his duty to teach the logic of Aristotle, whom he very strenuously defended against the attacks of Ramus. This office he resigned at the expiration of four years, and afterwards prosecuted his theological studies on the Continent. Having landed at Dantzig, he travelled through a great part of Prussia and Poland. He studied in several of the universities, particularly those of Helmstädt and Heidelberg. He rendered himself familiar with the writings of the fathers and schoolmen; and in the Hebrew language he became a great proficient. After spending four years in Germany, he went to Holland, and visited the university of Leyden, where his relation Dr Jack was then a professor of philosophy; and thence he sailed for England. From London he proceeded to Oxford, where his learning was held in so much estimation that he was offered the professorship of Hebrew in that university; but his countryman Dr Craig, physician to the king, advised him to consult his health by returning to his native air; and he accordingly arrived at Aberdeen, after an absence of five years. The corporation immediately conferred upon him the freedom of the city. When his health was in some measure restored, he was appointed minister of Alford, whence he was removed to Monymusk. He soon acquired the reputation of a most eloquent preacher, and after a short interval he became one of the ministers of Aberdeen. During the king's visit to St Andrews in the year 1617, Forbes was created D.D.; and not long after, he was nominated principal of Marischal College, where he not only read lectures in divinity, but likewise taught Hebrew. After retaining the office for two years, he was induced to accept of a pastoral charge in Edinburgh, where, however, he soon discovered that his character and doctrines were held in much less estimation than in his native city. Aberdeen was the stronghold of Episcopacy, and its clergy were among the most learned and respectable of the Episcopalians; but in Edinburgh the Presbyterians were the predominant party, and Dr Forbes therefore found himself placed in a situation far from agreeable. When he already thought of resigning his living, his old friends at Aberdeen induced him to resume his spiritual labours among them, and there he continued to reside till near the close of his life. When King Charles visited Edinburgh in the year 1633, Forbes was one of those who preached before him; and the king was so much struck with his eloquence, that when he erected the new see he spontaneously nominated him as the first bishop. His patent bears the date of January 26, 1634; but he was not long permitted to enjoy his new dignity: he died on

[1] Burnet's *Life of Bedell*, pref.
[2] Cave, *Historia Literaria*, p. xxx.
[3] Orem's *Description of King's College, Aberdeen*, p. 85.

the 11th of April, before he had completed the third month of his episcopate, and when he had only attained the forty-ninth year of his age. His remains were interred in the cathedral church of St Giles.

Bishop Forbes was a man of very extensive reading, but he did not himself publish any work. Twenty-four years after the author's death, however, Thomas Sydserf, bishop of Galloway,[1] published "*Considerationes modestæ et pacificæ Controversiarum de Justificatione, Purgatorio, Invocatione Sanctorum et Christo Mediatore, Eucharistia*, per Gulielmum Forbesium, S. T. D. et Episcopum Edinburgensem primum. Opus posthumum, diu desideratum." Lond. 1658, 8vo. The preface, subscribed T. G., that is, Thomas Gallovidiensis, is followed by an account of the author's life. This volume, which was reprinted at Helmstädt in the year 1704, attracted a very considerable degree of attention. and is mentioned by many of the continental writers.[2] The character of the learned author has thus been drawn by Bishop Burnet: "He was a grave and eminent divine: my father, that knew him long, and being of council for him in his law-matters, had occasion to know him well, has often told me, that he never saw him but he thought his heart was in heaven, and he was never alone with him but he felt within himself a commentary on these words of the apostles, 'Did not our hearts burn within us while he yet talked with us, and opened to us the Scriptures?' He preached with a zeal and vehemence that made him forget all the measures of time; two or three hours was no extraordinary thing for him; those sermons wasted his strength so fast, and his ascetical course of life was such, and he supplyed it so scantily, that he dyed within a year after his promotion; so that he only appeared there long enough to be known, but not long enough to do what might have been otherwise expected from so great a prelate. That little remnant of his that is in print shews how learned he was. I do not deny but his earnest desire of a general peace and union among all Christians has made him too favourable to many of the corruptions in the Church of Rome: but tho' a charity that is not well balanced may carry one to very indiscreet things, yet the principle from whence they flowed in him was so truly good, that the errors to which it carried him ought to be either excused, or at least to be very gently censured."[3]

FORCE, in *Philosophy*, denotes the cause of change in the state of a body, when, from being at rest, it begins to move, or has a motion which is either not uniform or not direct. While a body remains in the same state, either of rest or of uniform and rectilinear motion, the cause of its remaining in such a state is in the nature of the body, and it cannot be said that any extrinsic force has acted on it. This internal cause or principle is called *inertia*. See MECHANICS, and PHYSICS, § *Mechanical Philosophy*.

FORCEPS (Lat.), literally a pair of pincers or tongs. In surgery, an instrument for extracting things from wounds, &c. Also a pair of scissors for cutting off or dividing the fleshy membranous parts of the body.

FORCER, in *Mechanics*, a solid piston (without a valve) applied to pumps for the purpose of producing a constant stream, or to raise water to a greater height than it can be raised by the pressure of the atmosphere. See PUMP.

FORCHHEIM, a fortified town of Bavaria, circle of Upper Franconia, situated near the junction of the Wiesent with the Regnitz, 16 miles S.S.E. of Bamberg. It has a castle, a collegiate and two other churches, synagogue, monastery, hospital, and considerable trade and manufactures. In the middle ages several diets and councils of the church were held here. Pop. about 3500.

FORD, JOHN, a distinguished dramatic author, was born in 1586 at Ilsington, in Devonshire. Little is known of his personal history, but that he was educated for the bar, became a member of the Middle Temple in 1602, and continued to devote himself to his profession as a means of support while prosecuting his labours as a dramatic littérateur. His earliest efforts as a writer for the stage were in joint authorship with Dekker and Webster; but thirteen plays are understood to have been exclusively his own. The *Lover's Melancholy* appeared in 1628; the *Brother and Sister*, the *Broken Heart*, and *Love's Sacrifice*, in 1633. These were followed by the spirited historical drama, *Perkin Warbeck*. *Fancies Chaste and Noble* appeared in 1638, and the *Ladie's Trial*, which was his last work, in 1639. He is supposed to have died shortly afterwards. It is generally admitted that Ford's greatest drama is that called *'Tis Pity She's a Whore*. The unpleasant title indicates a plot still more repugnant to modern taste and feeling, embodying the development of an incestuous passion; but the poetry is of the highest order. The scenes in the *Brother and Sister*, in like manner, descriptive of the criminal loves of Annabella and Giovanni, are painfully interesting, and abound with passages of exquisite pathos and tenderness. It was usual with the old dramatists to employ their genius upon such themes as kindled the fires of passion. They lived in an age of excitement, and withdrew not themselves to study in retirement while the fierce conflict was raging around them between the newly awakened intellect and the long indulged appetites. With them the passion of love was a quenchless fire, before which the decencies of life were but as stubble; and though often wild and unnatural, it was not seldom imbued with preternatural sweetness as well as fervour. Nor even was the light of religion wholly quenched; there were glimpses of heaven in the midst of their darkest scenes of vice. Ford was pre-eminent among them for spending his poetic strength and building his reputation on unnatural and objectionable themes; but though his imagination was thus morbid, his personal deportment is said to have been by no means irregular; and Mr Hartley Coleridge suggests that it may merely have been as an exercise of intellectual power that he chose such horrible stories for his two best tragedies; and that "his moral sense was gratified by indignation at the dark possibilities of sin, and by compassion for rare extremes of suffering."

FORDINGBRIDGE, a market town of Hampshire, on the Avon, which is here crossed by a stone bridge of seven arches, 19 miles N.W. of Southampton, and 89 miles from London. It has some manufactures of sail-cloth and tickings; flax-mills; and calico-printing works. Market-day Friday. Pop. of parish (1851) 3178.

FORDUN, JOHN, the venerable father of Scottish history, apparently derived his surname from a village in the county of Kincardine, where he is supposed to have been born. He was a secular priest; and in some manuscripts of his history he is described as a chaplain of the cathedral of Aberdeen; a title which Goodall seems to have considered as equivalent to canon. Bower describes him as a simple man, who had never graduated in the schools. He was engaged in the composition of his work towards the close of the fourteenth century. The first five books, and twenty-three chapters of the sixth book of the Scotichronicon, are the composition of Fordun: for the remainder of the work in its present form, we are indebted to Walter Bower, who was born at Haddington in the year 1385, and was unanimously elected abbot of St Colm in the year 1418. This monastery, situated in a small island in the Firth of Forth, belonged to the canons regular of St Augustin. The

[1] Baillie's *Letters and Journals*, vol. ii., p. 426.
[2] *Bibliotheque Choisie*, tom. v., p. 396. Bayle, *Dictionnaire Historique et Critique*, tom. ii., p. 1194.
[3] Burnet's *Life of William Bedell, D.D., Bishop of Kilmore*, pref. Lond., 1685, 8vo. A portrait of Bishop Forbes may be found in Pinkerton's *Iconographia Scotica*, or *Portraits of Illustrious Persons of Scotland*. Lond., 1797, 4to.

abbot is sometimes called Bowmaker, which is equivalent in signification to Bower. From 1395 to 1399 John Bowmaker appears as the deputy of the bailies or of the *customars* of Haddington, at the presentation of their accounts. As the first of these dates is only ten years subsequent to the abbot's birth, and as he was a native of that town, this individual might possibly be his father or other relation. At the request of Sir David Stewart of Rossyth, he undertook to transcribe the papers of Fordun; but instead of executing a mere transcript, he inserted large interpolations, and continued the narrative to the death of James the First, having thus extended the work to sixteen books. Of this continuation the principal materials had however been collected by his predecessor. Bower professes to have been careful to distinguish what belonged to each; but as the negligence of subsequent copyists has omitted all his marks, we must chiefly be guided by the internal evidence in adjusting their respective claims. The Latinity of the Scotichronicon, though certainly far from being classical, is less barbarous than that of many other chronicles of the middle ages. Winton, the author of a chronicle in Scottish verse, is perhaps a more judicious writer than either Fordun or Bower, though his share of credulity and superstition is by no means inconsiderable. Beyond this period we have scarcely any records professedly historical, except the Chronicle of Melrose, and a few other fragments, neither considerable for their value nor extent.

It would be endless, as Nicolson has remarked, "to compute into how many several chronicles this of Fordun's has been multiply'd: for, being in every monastery of the kingdom under the anonymous title of *Scoto-chronicon*, it commonly borrowed a sirname from the place to which it belong'd."[1] The Black Book of Scone, and the Black Book of Paisley, were copies which obtained no small celebrity, and which seem to have been commonly regarded as two distinct chronicles compiled in those two monasteries. Thus, the Book of Pluscardine was a copy belonging to the priory of that name. Magnus Macculloch and Patrick Russell, who are sometimes mentioned as continuators, were in all probability little more than transcribers of Fordun.

Some portions of the Scotichronicon were inserted in the collection of Dr Gale,[2] who obtained a defective copy, which he supposed to have belonged to Hector Boyce. In the year 1719, Richard Hay, a canon regular of St Augustin, issued "Proposals for Printing the Chronicle of John Fordun, with the Additions and Continuation of Walter Bowmaker, Abbot of Inch-Colm, containing the memorable things which happened in every year, since our first rise, to King James the First's death; conform to an authentick manuscript, belonging of old to one of our decay'd monasteries: with several notes, for clearing the dark parts of our history." The manuscript, "a large folio, written in old, but in glorious characters," belonged to the Cistertian monastery of St Mary at Cupar in Angus: it afterwards came into the possession of Hay, and was deposited in the Advocates' Library. He concludes his Proposals in the following manner: "Many persons of an eminent character have appeared desirous to have it printed, because what copies thereof were carried to England, France, Flanders, Italy, and elsewhere, during the heat of the Reformation, or our late disturbances, are probably lost for us. And what remain in the country, in private hands or in particular libraries, are of no use to the publick, whilst they are shut up, and as if it were hidden in obscure places, where scarce any number of men of an ordinar capacity are allowed access. Therefor I have been willing to publish this manuscript, with several notes, for the greater intelligence of our history, and a large preface, where I shall give an exact account of the fate and fortune of the most part of the others, transcribed by different hands, in former ages, with whom I have compared this original. The charges and expences of publishing this book will be certainly considerable. So those that are pleased to further and incourage this enterprize, are desired to pay ten shillings sterling at subscribing, and as much at the delivery of the printed copy, which will prove a good folio, on fine paper, and in good caracters, and will consist of 160 sheet and above. Their names and designations shall be insert in the front, and their respective houses or families shall be kindly remembered in the notes. As to the subscriptions, they are to be taken by the author, at his lodging in Howison's Land in the Potterraw; by Mr John Mackenzie of Delvin, at his lodging in the Parliament Close; by Mr Henry Massie, merchant, near the foot of Blackfriar-Wynd; by Mr William Adams, printer, over against the Trone-Church; by Mr Ruddiman in the Advocates' Library; who shall deliver to the persons concerned the author's obligation to have the compleat copy remitted to them about the end of the following year, 1720, they paying ten shillings more at the time appointed." This plan was never carried into execution; but a valuable edition was soon afterwards published by Hearne, under the title of "Johannis de Fordun Scotichronicon genuinum, una cum ejusdem Supplemento ac Continuatione." Oxon. 1722, 5 tom. 8vo. The editor proceeds upon the plan of separating the interpolations of Bower from the text of Fordun. After an interval of nearly forty years, another edition was published by Walter Goodall, assistant-keeper of the Advocates' Library: "Joannis de Fordun Scotichronicon, cum Supplementis et Continuatione Walteri Boweri, Insulæ Sancti Columbæ Abbatis." Edinb. 1759, 2 tom. fol. Goodall chiefly adheres to an excellent manuscript, written on vellum, and preserved in the library of the university of Edinburgh. (D. I.)

FORDYCE, DAVID, professor of moral philosophy in Marischal College, Aberdeen, was born in that city in 1711. Having received the early part of his education at the grammar-school, he, at the age of thirteen, entered the Greek class in Marischal College, Aberdeen; in 1728 he took the degree of master of arts, and in 1742 he was admitted professor of philosophy in the same college. Being originally designed for the church, he applied himself with great ardour to the study of divinity, in which he made great progress, though he never became a settled minister in the establishment of his native country. That he was well qualified to be such, however, appears from his *Theodorus*, a dialogue concerning the art of preaching, which he afterwards published. In 1750 he went abroad on his travels, in order to obtain fresh stores of knowledge; but after a successful tour through several parts of Europe, he was, on his return home, unfortunately cast away in a storm on the coast of Holland, in the forty-first year of his age. Besides the above work, he wrote *Dialogues on Education*, 8vo, and a Treatise on Moral Philosophy, published in the *Preceptor*. The third edition of his *Theodorus* was published in London, after his death, by his brother James, the subject of the following article.

FORDYCE, *James*, a Scottish clergyman of considerable eminence, was born at Aberdeen in the year 1720. He received his classical education at the public grammar-school, and afterwards entered Marischal College, where he went through the course of studies necessary to qualify him for being a minister of the gospel. His natural abilities were excellent; and having improved to the utmost the favourable opportunities he enjoyed at the university, he was considered as qualified for becoming a preacher of the gospel at an early period of life. His first appointment was that of second minister of Brechin, in the county of Angus, after which he accepted of a call to Alloa, near Stirling. The

[1] Nicolson's *Scottish Historical Library*, p. 92.

[2] *Historiæ Britannicæ Scriptores XV.*, vol. i., p. 565.

people of this parish were prepossessed in favour of another, and prejudiced against Mr Fordyce, which could not fail to prove an unpleasant circumstance; yet by his impressive delivery, and indefatigable attention to every part of his ministerial duty, he soon overcame their prejudice, and acquired their esteem and admiration.

During his residence at Alloa, he attracted the notice of the public by three sermons; the first on the eloquence of the pulpit, the second on the method of promoting edification by public institutions, and the third on the delusive and sanguinary spirit of popery, preached before the synod of Perth and Stirling. But still greater admiration was excited by his sermon on the folly, infamy, and misery of unlawful pleasure, preached before the General Assembly of the Church of Scotland in 1760. About this time the university of Glasgow conferred upon him the degree of doctor of divinity, probably on account of the fame he had acquired by this sermon.

The friends of Dr Fordyce being mostly in the metropolis, he was invited to become the colleague of Dr Lawrence, minister of a respectable congregation in Monkwell Street, London, on whose death, which happened a few months afterwards, Dr Fordyce became once more celebrated for his pulpit eloquence, generally preaching to overflowing audiences. The best specimen of pulpit eloquence which perhaps proceeded from his pen was delivered at the ordination of Mr James Lindsay, who, after Fordyce declined officiating as a minister, became his successor. The remainder of his life he spent chiefly in retirement in Hampshire, in the vicinity of the residence of Lord Bute, with whom he lived on the greatest intimacy, and to whose valuable library he had unrestricted access. He afterwards went to Bath, where he suffered much from an asthmatic affection, which he bore with the fortitude of a Christian, and expired without a groan on the 1st of October 1796, in the seventy-sixth year of his age.

The Doctor's writings discover much genius and a correct taste, extensive knowledge of the world, and a happy method of engaging the attention. He was the author of *Sermons to Young Women*, 1765, in 2 vols. 12mo; *A Sermon on the Character and Conduct of the Female Sex; Addresses to Young Men*, 1777, in 2 vols. 12mo; *Addresses to the Deity*, 1785, in 12mo; *A volume of Poems; A discourse on Pain*, 1791; and *Additions to his brother's Temple of Virtue.*

Fordyce, George, a writer and lecturer on medicine, was born at Aberdeen in 1736, and studied at the university of that city, where he took the degree of master of arts at the early age of fourteen. He became apprentice to an uncle who practised surgery at Uppingham in Rutlandshire, when he was only fifteen; and afterwards went to the university of Edinburgh, where his diligence and progress attracted the attention of Dr Cullen, at that time professor of chemistry, who very generously promoted his improvement. He graduated in 1758, when only twenty-two years of age; after which he resided during one winter at Leyden. The greater part of his patrimony having been spent on his education, he resolved to try his fortune in London, where he settled in the year 1759. He commenced with a course of lectures on chemistry; and although his encouragement at first was by no means flattering, yet he steadily and diligently persevered, notwithstanding unfavourable appearances, till his literary merit began gradually to be discovered and appreciated. A number of young men who came to study in London did not think that their medical course was complete without availing themselves of the benefit of his lectures. In 1768 he published his *Elements of the Practice of Physic*, which formed the text-book of his medical course, and were much read as a valuable epitome of medicine. His private practice was very respectable; and in the year 1770 his medical reputation was so great that he was chosen physician to the hospital of St Thomas, although he had to contend against a gentleman with very powerful interest; whilst his merit as a man of science procured him admission as a member of the Royal Society in 1776. In 1787 he was chosen a fellow of the College of Physicians; and his chemical knowledge was of much importance to that body in preparing a new edition of their Pharmacopœia. By the influence of his connections, but probably more so by his literary reputation, he was appointed to furnish the navy with sour krout, which we believe he executed with advantage both to himself and to the public. By this time, however, his constitution had discovered symptoms of premature decay; yet he continued to discharge his professional duties till he fell a victim to an irregular gout, and water in the chest, on the 25th of June 1802, in the sixty-sixth year of his age. If his lectures wanted the charms of eloquent delivery, he made amends by the originality of his ideas and the extent of his scientific information. His works are, *Elements of Agriculture and Vegetation; Elements of the Practice of Physick; A Treatise on the Digestion of Food; Four Dissertations on Fever*, to which has been added a fifth, published from his manuscript since his death. His other works appeared in the *Philosophical Transactions*, to which he contributed eight papers, and in the *Medical and Chirurgical Transactions*, to which he contributed three.

FORECASTLE, that part of the upper deck of a ship forward of the foremast. Also, in merchant vessels, the forward part of the ship under the deck, where the sailors live.

FOREIGNER, the natural-born subject of a foreign state. Foreigners, though made denizens, or naturalized, are disqualified from bearing any office in government, from being of the privy council, sitting in parliament, &c. See Denizen.

FOREJUDGER, in *Law*, a judgment by which a person is deprived or put out of the thing in question.

FORELAND, North and South, two headlands on the east coast of the county of Kent. North Foreland consists of chalky cliffs nearly 200 feet in height, and has a lighthouse with a fixed light 184 feet high, and seen 24 miles off. South Foreland is about 16 miles south of the former, and has two lighthouses 1347 feet apart, and 380 and 275 feet high, visible 25 and 22 miles off.

FORE-LOCK, in nautical language, a flat wedge of iron, driven through the end of a bolt to prevent its drawing.

FOREMAST, the forward mast of all vessels.

FOREST, a large extent of ground covered with trees. The word is formed from the base Latin *foresta*, which first occurs in the capitulars of Charlemagne, and is itself derived from the German *forst*, signifying the same thing. Vossius and Spelman refer it to the Latin *foris*, as being *extra urbem et agros.*

The Caledonian and Hercynian forests are famous in history. The former was a celebrated retreat of the ancient Picts and Scots; and the latter, in Cæsar's time, extended from the borders of Alsatia and Switzerland to Transylvania, being computed at sixty days' journey in length and nine in breadth. The ancients had a superstitious veneration for forests, as being the favourite abodes of many of their gods. Temples were frequently built in the thickest forests, the gloom and silence of which were calculated to inspire sentiments of devotion. For a similar reason the Druids dwelt in forests, performing sacrifices, instructing youth, and giving laws in their umbrageous recesses.

Forest, in *Law*, is defined by Manwood, "a certain territory or circuit of woody grounds and pastures, known in its bounds as privileged for the peaceable being and abiding of wild beasts and fowls of forest, chase, and warren, to be under the king's protection for his princely delight; bounded with unremoveable marks and meres, either known by matter of record or prescription; replenished with beasts

of venery or chase, and great coverts of vert for succour of the said beasts; for preservation whereof there are particular laws, privileges, and officers belonging thereunto." Forests are of such antiquity in England that, excepting the New Forest in Hampshire, erected by William the Conqueror, and Hampton Court, erected by Henry VIII., there is no record which makes any certain mention of their erection, though they are often alluded to by various writers, and in several of our laws and statutes. Ancient historians tell us that New Forest was raised by the destruction of twenty-two parish churches, and many villages, chapels, and manors, for the space of thirty miles together, which was attended with divers judgments on the posterity of William I., who erected it; for William Rufus was there shot with an arrow, and before him Richard, the brother of Henry I.; and Henry, nephew to Robert, the eldest son of the conqueror, was, like Absalom, suspended by the hair of the head in the boughs of the forest. The Conqueror, says the 'Saxon Chronicle,'—"loved the red deer as if he had been their father;" and he is said to have visited the slaughter of one of these animals with greater severity than murder itself. This king is said to have possessed in different parts of England no fewer than sixty-eight forests, besides an immense number of chases and parks.

Legally, a forest can only be in the hands of the sovereign; for the sovereign alone has power to grant a commission to be justice in eyre of the forest. A chase differs from a forest in being capable of being held by a subject, in being of smaller extent, and subject to the common law, and not to the forest laws. A chase also may be comprised within a forest.

Forest-Laws, are peculiar laws, different from the common law of England. Before the making of the *Carta de Foresta* (granted by Henry III. A.D. 1224, and confirmed by Edward I. in 1299), offences committed in the forest were punished at the pleasure of the king in the severest manner. By this charter many forests were disforested and stripped of their oppressive privileges, and regulations were made for the government of those which remained; in particular, killing the king's deer was declared to be no longer a capital offence, but only punishable by fine, imprisonment, or abjuration of the realm. Still, in this charter there were some grievous articles, which, however, were modified by the clemency of later princes; and indeed the forest laws may now be said to be practically abolished.

FORESTALLING, in *Law*, is, by statute 5th and 6th Edw. VI., c. 14, described to be the buying or contracting for any merchandise or victual coming in the way to market; or dissuading persons from bringing their goods or provisions there; or persuading them to enhance the price when there. This, as well as *engrossing*, which is the buying up of large quantities of corn, or other dead victuals, with intent to sell them again, and *regrating*, the buying up of such commodities in any market, and selling them again in the same market, or within four miles of it, was looked upon as injurious to the public, by unnecessarily tending to raise the price of provisions; and accordingly several statutes were passed prohibiting forestalling under severe penalties. Statute 31st Edw. I. enacted that "no forestaller shall be suffered to dwell in any town who manifestly is an oppressor of the poore, a publike enemie of the whole comminaltie and countrie, who meeting grain, fish, herring, and other things coming by land or by water to bee solde, doeth make haste to buy them before other, thirsting after wicked gaine, oppressing the poore, and deceiuing the rich." By the statute of Edw. VI. already referred to, it was enacted that whoever should buy any corn or grain with intent to sell it again, should for the first offence suffer two months' imprisonment, for the second, six months' imprisonment, and forfeit double its value, and for the third, be set in the pillory, suffer imprisonment during the king's pleasure, and forfeit all his goods and chattels. This statute further enacted that no one could transport corn from one part to another without a licence, ascertaining his qualifications as a man of probity and fair dealing.

The very imperfect knowledge of political economy that then prevailed led to the belief that the intervention of a third party between the producer and consumer tended to raise the price of provisions, and that corn would be bought from the farmer cheaper than from the corn-merchant. It may seem somewhat strange that though the law thus compelled the farmer to deal directly with the consumer, yet it in many cases prohibited the manufacturer from selling his own wares by retail, in order that the shopkeepers might not be undersold. The farmer was thus forced to carry on two trades; and part of the capital which should have been employed in the improvement and cultivation of land was obliged to be kept in his granaries and stockyard: whereas the corn-merchant, by affording a ready market for the farmer's produce, enables him to employ his whole capital in cultivation; and the existence of a free competition obliges the corn-merchant to sell his corn as cheap as the farmer could afford to do. The principle here is the same as in manual labour. The workman who is wholly employed in one operation accomplishes a greater quantity of work, and can afford to do it at a cheaper rate, than one who has to carry on several operations; and, in the same way, the dealer whose whole stock is employed in a single branch of business acquires so easy and ready a method of transacting business that, with the same capital, he can carry on a much larger business, and so dispose of his goods cheaper than if his capital and attention were employed in a greater variety of objects. "If," says Adam Smith, "a merchant ever buys up corn, either going to a particular market, or in a particular market, in order to sell it again soon after in the same market, it must be because he judges that the market cannot be so liberally supplied through the whole season as upon that particular occasion, and that the price therefore must soon rise."

The rigour of the statute of Edward VI. was very much softened by subsequent statutes, which successively permitted the engrossing of corn when the price of wheat should not exceed 20s., 24s., 32s., and 48s. the quarter; and statute 12th Geo. III., cap. 71, repealed the restrictions and penalties imposed by previous statutes, which by preventing a free trade in corn and other victuals, had a tendency to discourage the growth and enhance the price of the same. This statute, however, did not declare that these offences should no longer be indictable at common law; and hence we find that when, in 1800, the price of corn rose to an unusual height, the clamour against the corn-dealers was so loud that one of the name of Rusby was indicted for the offence of regrating, though he was not brought up for judgment. It was not till the passing of the act 7th and 8th Vict., cap. 24, that the several offences of badgering, engrossing, forestalling, and regrating, were utterly taken away and abolished. It declares "that no information, indictment, suit, or prosecution, shall lie either at common law, or by virtue of any statute, or be commenced or prosecuted against any person for or by reason of any of the said offences or supposed offences."

FORFAR OR ANGUS, a county of Scotland, is bounded by the shires of Aberdeen and Kincardine on the north, the German Ocean on the east, the Firth of Tay, which separates it from Fife, on the south, and by Perthshire on the west. It is situated between 56° 27′ and 57° north latitude, and between 2° 28′ and 3° 22′ west longitude from Greenwich, and extends from north to south about 36 miles, and from east to west 27 miles. It contains, according to the agricultural statistics taken in 1854, 457,054½ imperial acres, of which 5843½ acres are let to small holders under L.10 of rent. Excluding the latter,

the acreage is occupied as follows: 89,361 in cereals, or white crop; 1601½ in beans, pease, and vetches; 32,200 in turnips; 12,530 in potatoes; 63 in mangold, carrots, and cabbage; 136 in flax; 77,350 in grass under rotation; 27,225 in permanent pasture; 106,809 in sheep walks; 69,940 waste; 26,604 woods; the remainder being occupied by houses, roads, &c. More than one-third of its area is occupied by sheep-walks and waste ground, forming part of the Grampian range, here called the Binchinnin hills, which join the Braes of Mar in Aberdeenshire. The surface of this northern division of the county, or the Braes of Angus, with the exception of the mountains at the head of Glen Clova, is not in general so bold and abrupt as many other Alpine districts in Scotland; the hills are for the most part rounded, and rather tame, and covered with a thin coat of moorish soil, bearing stunted heath. Catlaw, the highest, is 2264 feet above the level of the sea. There are several considerable valleys in this district, the principal of which are Glen Isla, Glen Prosen, Glen Esk, Clova, and Lethnot, which are watered by streams that rise in the west and north, and commonly flow south-east, receiving innumerable torrents from the mountains in their progress. South from the Grampians; and parallel to them, is another but lower range, called the Siedlaw Hills, supposed to be a continuation of the Ochils: some of these are 1400 feet in height. Between these two grand divisions lies Strathmore, the Great Valley, as the name in Gaelic denotes, or as it is commonly called the How of Angus, forming a continuation of the How of the Mearns, extending about 33 miles in length, and from six to eight in breadth; a district beautifully diversified by gentle eminences, fertile fields, plantations, villages, and gentlemen's seats, very little of it being 200 feet above sea-level. The Aberdeen and Scottish Midland Railways run along this valley, from which there are branches to Arbroath, Dundee, Kirriemuir, Blairgowrie, &c. The fourth and remaining division extends from the Siedlaw Hills to the German Ocean on the east, and the Firth of Tay on the south, and is, with a few exceptions, a rich and well-cultivated tract, varying in breadth from three to eight miles, and comprehending about a fourth part of the whole country.

The general colour of the soils in the lower districts is red, in other parts often inclining to dark brown or black. The soil in the Grampians is generally moorish over whitish retentive clay, but loose, friable, and productive in the glens. Over the pudding-stone, or farcilite rock, in the lower grounds, it is sometimes thin, mossy, and encumbered with stones, and over the sandstone a tenacious clay often occurs. The soil above whinstone is fertile, though sometimes shallow. There is no great extent of moss, the greater part of it having been drained and cultivated during the last twenty years.

The mineralogy of a considerable portion of Forfarshire was examined by Colonel Imrie, who has given a minute description of it in a paper published in the sixth volume of the *Transactions* of the Royal Society of Edinburgh. In the Grampian districts, towards the summit of the county, on the confines of Aberdeenshire, the prevailing rock is granite, some of it very beautiful, and containing in its cavities or fissures topazes and rock-crystals called cairngorms, from a mountain of that name in Aberdeenshire; also micaceous schistus, and porphyry, dykes of the latter in some places intersecting the former. Laminated mica, called by the natives *sheep's siller*, from its silvery lustre, is found in veins, in mica slate, and the rock-crystals are found in the beds of torrents. Lead was once wrought at Gilfianan, above the old castle of Invermark, in the upper part of the parish of Lochlee, and also at Ardoch, near Millden on the Esk. At the former place, according to Edward, in his *Description of Angus*, published in 1678, it yielded one sixty-fourth part of silver; but both mines have long since been abandoned. Limestone in small quantities here frequently occurs, but is now seldom or never worked. There are also broad beds of slate, but which, from some imperfections, is of little use. In descending the Grampians to Strathmore, pudding-stone prevails; and afterwards on the lower grounds, sandstone. Clay marl is found both in Strathmore and the Siedlaw hills, but is little used. Shell marl, which is the remains of myriads of small testaceous animals, is in greater request, although not so much now as some years ago: it abounds in different parts, particularly in the lochs of Kinordie, Lundie, Logie, near Kirriemuir, and Restennet near Forfar. These lochs have been partly drained, and the marl rendered of easy access. It is also found in the lochs of Forfar, Rescobie, and Balgavies, where it is raised by scoops, and conveyed to the shore in boats. The Siedlaw hills are chiefly composed of sandstone of various colours. Sandstone flags, which are much used for roofing houses, are raised in great quantities on the Hill of Balmashanner, in the moor to the south of Forfar, in the parish of Carmylie, and along the southern declivity of the Siedlaw hills. The principal lime-works are in the maritime division at Hedderwick, near Montrose, and at Boddin, in the parish of Craig. The only mineral springs worth noticing are chalybeate, one of which is near Montrose, another to the west of Arbroath, two in the side of a rivulet about a mile farther west, and one in the north-west corner of Dumbarrow, in Dunnichen parish.

The botany and zoology of the county were explored with great industry a good many years ago by Mr George Don of Forfar, who presented a very ample enumeration in both departments, in a paper subjoined to Mr Headrick's survey for the *Board of Agriculture*. A few years ago the late Mr Wm. Gardiner of Dundee, a good botanist and florist, published a small useful work on the botany of Forfarshire.

The most prevailing rains are from the east and south-east, as experienced all along the east coast of Scotland. At Crescent, half a mile westward of Dundee, the quantity of rain that fell during six years, from 1790 to 1795 inclusive, varied from 22·27 to 34·12 inches; but at Belmont, in the centre of Strathmore, during the same years, it was from 31·45 to 39·55 inches. The mean height of the barometer at Belmont during the first three of these years was 29·60°, and that of the thermometer 42°. At Crescent, the mean degree of cold during winter for the whole period was from 32½° to 39¾°, and of heat during summer, from 60½° to 66°. The south-east wind blows at Crescent 21 days, and the south-west 109 annually; whereas at Belmont the former prevails 85, and the latter 138 days. It may be interesting to add the following meteorological observations, taken with great accuracy by Mr Alexander Brown, writer, Arbroath, for the ten years inclusive from 1845 to 1854. The situation was 50 feet above the level of the sea, and about half a mile distant from it.

Barometer.

Reduced to Temperature of 32°, and Corrected.

Years.	Spring.	Summer.	Autumn.	Winter.	Mean.
1845	29·86	29·66	29·78	29·74	29·76
1846	29·75	29·58	29·72	29·93	29·74
1847	29·72	29·69	29·77	29·77	29·74
1848	29·71	29·71	29·92	29·93	29·82
1849	29·92	29·74	29·84	29·94	29·86
1850	29·89	29·71	29·85	29·84	29·82
1851	29·88	29·76	29 93	30·01	29·89
1852	30·05	29·78	29·70	29·93	29·86
1853	29·88	29·80	29·81	29·83	29·83
1854	29·97	29·86	29·82	29·84	29·87
Mean	29·86	29·73	29·81	29·87	29·82

On the 22d December 1849, the barometer stood at 30·96; and on the 27th December 1852 it stood 28·00.

Temperature.

By average of Self-registering Thermometer, 11 feet from ground.

Years.	Spring.	Summer.	Autumn.	Winter.	Mean.
1845	42°4	54·5	46°4	39°1	45°6
1846	44·4	59·4	48·7	34·3	46·7
1847	43·7	57·4	46·3	35·8	45·8
1848	44 5	54·4	45·1	38 0	45·5
1849	43·5	53·5	44·3	36·0	44·3
1850	43·2	55·8	46·8	39·3	46·3
1851	44 5	55·6	46·2	37·5	45·9
1852	43·8	58 0	45·6	36 0	45·8
1853	43·0	58·3	46·6	35·8	45·9
1854	45·9	57 0	46·4	33·5	45·7
Mean	43·9	56·4	46·2	36·5	45·7

The maximum heat was on 14th July 1847, 83°; the minimum on 17th February 1855, 4°. At Arbroath, daily observations of the thermometer made at 8^{h} 20^{m} A.M., and 7^{h} 35^{m} P.M., local mean time, give the mean annual temperature of the year.

Depth of Rain in Inches.

Rain-Gauge 3 feet from ground.

Years.	Spring.	Summer.	Autumn.	Winter.	Total.
1845	1·620	9·021	8·926	4·840	24·407
1846	6·152	8·103	10·787	3·494	28·536
1847	7·016	5·167	5·506	12·808	30·497
1848	6·105	9·823	7·242	6·793	29·963
1849	4·514	6·857	4·530	8·033	23·934
1850	4·490	5·764	6·239	6·212	22·705
1851	7·280	7·308	3·481	6·869	24·938
1852	2·323	6·120	9·186	11·525	29·154
1853	3·043	7·515	9·128	5·242	24 928
1854	3·897	5·744	6·417	4·220	20·278
Mean.	4·644	7·142	7·144	7·004	25·934

Dew-point.

Deduced from observations of Wet and Dry bulb Thermometer.

Year.	Spring.	Summer.	Autumn.	Winter.	Mean.
1854	39°·9	52°·1	40°·9	25°·2	39°·5

Average Direction of Wind, and Number of Fair and Rainy Days, from 1845 *to* 1854 *inclusive.*

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	Total.	Fair.	Rainy.
38·5	27·5	22·8	39·4	57·7	56·	61·5	40·	21·6	365	218½	146½

The above tables will assist in forming a pretty correct idea of the climate of this county, which is one generally favourable to the production of white and green crops of all kinds, and salubrious.

In addition to the lochs or lakes already mentioned, there are other two considerable ones—viz., Lochlee, among the Grampians, from which the North Esk issues, and Lentrathen near their base. This river, after leaving Lochlee, flows towards the east and then the south-east, where it forms the boundary between this county and that of Kincardine, and falls into the sea about three miles north-east of Montrose, having received in its course the Mark, the Tarf, the Westwater, the Cruik, the Luther, and other smaller streams. The South Esk rises in the north-western part of the county among the Grampian summits of Clova, and passing by Brechin, discharges itself into the basin of Montrose, after being joined by the waters of Prosen, Carrity, and other mountain and a few lowland streams. Its general course is from north-west to south-east. Isla, the last stream of any note, has also its source in the Grampians, flowing from the summit of the glen which bears its name, in a direction from north to south, until at Ruthven it bends to the westward, and joins the Tay in Perthshire. Below the Bridge of Craig it has cut a chasm, in some places more than a hundred feet in depth, through a barrier of porphyry and gravel-stone rocks, where it forms cascades of singular beauty. The Dean, the Lunan, the Dighty, and a few others, are inconsiderable streams.

Much of the landed property of Forfarshire has changed its owners within the last century; and of the forty barons mentioned by Edward in the work already referred to, the descendants of not more than a third of them now possess estates in it, and most of these are considerably reduced in size. In 1811 a large proportion of the estates were from L.100 to L.1000 a year, some from L.2000 to L.6000, and only one or two worth L.12,000 a year. At that date about a third part of the county was held under entail, but the entail act has been taken advantage of extensively in effecting either actual sales, or in placing the properties in the *fee simple* possession of the owners. The valued rent in 1674 was L.171,239, 16s. 8d. Scots. At the above date there were 266 estates, three-fourths of which were below L.500 Scots.

The real rental of the lands in 1811 was set down at L.260,196, 15s., and of the houses L.64,108 sterling. The whole number of farms was then 3222, of which about the half were under L.20 of yearly rent, and only 86 above L.300. Since that period the tendency of landowners has been to add to the size of their farms by joining smaller ones together—a policy which, in some respects, has been much questioned. The rent of lands in 1853–4 was L.295,664; of quarries, fisheries, and other property, L.7952; and the yearly value of house-property was L.278,479. Total value of real property, L.582,095. There are more than sixty gentlemen's seats, some of them venerable for their extent and antiquity, such as the castles of Glammis, Brechin, Airley, &c.; and the castles of Kinnaird and Panmure are at present undergoing such repairs and additions as will render them among the most commodious and magnificent mansions in Scotland. There is one estate that yields above L.25,000 a year, and two or three from L.16,000 to L.20,000. The farms rent from L.1500 downwards. Great improvements have been made during the last twenty years in the erection of substantial farm-houses and steadings, but very little advance has been made in supplying suitable accommodation to either married or single farm-servants. A movement has lately been set on foot, which is only a revival of one or two similar attempts formerly made to remedy this evil, but the obstacles in the way are not easily overcome. The greatest of these is, doubtless, the want of capital (and in many cases disposition conjoined) to erect proper cottages; and to supply the means necessary for this purpose, the "Agricultural Labourers' Association" does not recommend any measure of relief by loan or otherwise.

Great advancement has, of late years, been made in this county in the science and practice of agriculture, and it contains a class of tenantry nowhere exceeded in Scotland for enterprise and intelligence. The system of rotation varies according to soil and situation. The five-course shift is that most usually adopted; but as guano and artificial manures are becoming more in use, there is less land kept in grass, and more sown in green crop. Wheat, which according to Pennant was a rare crop in 1775, is now much cultivated upon almost every variety of soil, to the height of more than 1000 feet above the level of the sea; while a

very small proportion is sown with bere or bigg, which, with oats, used to be the principal white crops sown. A corresponding progress has been made in the improvement of live stock. What is usually known as the Clydesdale or west country breed of farm-horses, is common in the lower districts. The *garron* and small highland breeds, so famous for their action and durability, are now almost extinct. Last year there were 9290 saddle and work horses, of the probable value of L.300,000; and, perhaps, 2000 colts and fillies, worth L.30,000. About fifteen or twenty years ago, the Angus, a black polled breed of cattle, was almost exclusively raised. These are well known and highly valued, being in the estimation of some agriculturists of note better suited in certain respects for a northern climate than the breeds more recently introduced, especially for *feeding* purposes, by crossing with a short-horn bull. Crossing, however, has become so common during the last ten or fifteen years, that the *pure* Angus breed is not easily obtained, except from a comparatively few agriculturists who have made breeding of first-class stock a main object, the most eminent of whom is Mr Watson of Keillor. Last year there were 13,764 milk cows, 25,605 other cattle, and 10,874 calves, in all 50,243, of which 2240 belonged to tenants under L.10 of rent. The total value may be estimated at above L.500,000, being nearly double of what they were reckoned to be worth twenty years ago. The flocks of black-faced sheep are considerable; and during the last few years sheep-grazing has become general in the lowlands—the Leicester, or a cross between them and the black-faced, being most in favour. There are of ewes, gimmers, and ewe-hogs, 53,169; and of tups, wethers, and wether-hogs, 51,349, which may be valued at upwards of L.100,000. There are few or no goats worth mentioning kept. The quantity of swine fed is limited, owing to there being few or no large dairy farms. The number is 8822, of which upwards of 1000 belong to the small holders. The value of swine may be L.10,000; and the total value of live stock within the county cannot be much under L.1,000,000 sterling.

Forfarshire contains five royal burghs—viz., Forfar, the county town, Dundee, Montrose, Arbroath, Brechin, together with a number of villages, such as Kirriemuir, Glammis, &c.

The fisheries on the coast for herring, white fish, and salmon, are prosecuted with considerable success.

Many religious and military ruins are to be found in Forfarshire. Among the former, the most celebrated are the remains of the Abbey of Arbroath. This building was founded and dedicated to Thomas à Becket in 1178 by William the Lion, whose ashes repose within its walls. It was richly endowed, and has some historical interest attached to it from having, among other incidents, been the place where was held the parliament of Robert Bruce, which addressed the celebrated remonstrance to the Pope asserting the independence of the kingdom. The abbey was destroyed before the Reformation in the sixteenth century. Beside the cathedral of Brechin is a curious round tower, of which, though such be common in Ireland, only two, it is said, have been observed in Britain—this and another one at Abernethy, in Perthshire. (See Brechin.) A hill called Cater-thun, in the parish of Menmuir, north-west of Brechin, is worthy of notice. Pennant thinks it was one of the posts occupied by the Caledonians before their engagement with Agricola, at the foot of the Grampians.

There are fifty-six parishes in the county. In 1833 there were about 20,000 communicants or members of the Established Church, and about 2300 dissenters. Since that period the number of church members has greatly decreased, a large proportion of them since the Disruption having become dissenters.

Among the eminent men connected with this county may be mentioned Hector Boetius, who was born in the parish of Panbride; Archbishop Leighton and Andrew Melville, born in the parish of Craig; the Marquis of Montrose, Joseph Hume, and Sir Alexander Burnes, born in Montrose; and in Mains and Strathmartine was the residence of Grahame of Claverhouse. The county sends one member to parliament, the burgh of Dundee one, and the other royal burghs, in conjunction with Bervie, one.

Twenty years ago there was no assessment levied for the poor within the county. One half of the parishes are now assessed. Last year the number of poor on the roll was 5172, for whose support L.25,976 were expended; and there were of casual poor 1454, who received L.1165. These sums amount to more than an eleventh part of the land-rental of the county, exclusive of the sum raised by voluntary assessment.

See Edward's *Description of Angus*, reprinted in 1791, and Colonel Imrie's *Section of the Grampians*, already referred to; *Beauties of Scotland*, vol. iv.; Headrick's *General View of the Agriculture of Angus or Forfarshire; Memoirs of the Wernerian Society*, vol. ii.; *The General Report of Scotland*; Playfair's *Description of Scotland*, vol. i.; and the old and new Statistical Account of Forfarshire. (J. C—E.)

The following are the returns of the population, &c., from 1801 to 1851:—

Year.	Houses. Inhabited.	Houses. Uninhabited.	Persons. Males.	Persons. Females.	Total of Persons.
1801	..	...	45,427	53,626	99,053
1811	16,135	505	48,115	59,072	107,187
1821	16,812	576	52,036	61,319	113,355
1831	19,597	945	65,093	74,513	139,606
1841	36,184	2071	79,343	91,110	170,453
1851	22,446	725	88,324	102,940	191,264

By the computation of 1841 *flats* were reckoned *houses*.

Forfar, a royal and parliamentary burgh of Scotland, and capital of the county of the same name, in the valley of Strathmore, on the line of the Aberdeen Railway. Forfar is of considerable antiquity, having been constituted a burgh before A.D. 1261. It was at one time a residence of royalty; and in the accounts of the chamberlain of the royal household a charge is entered for the king's gardener at Forfar. The town was protected by a castle, which stood on a mound on the north side. Its origin is uncertain; but it is said by Boyce to have been the place where, in 1057, the first parliament of Malcolm Caenmore assembled after the defeat of Macbeth.

The site of this ancient fortress is now marked by a circular building of modern date. The castle, which was surrounded with water, was occupied and strongly garrisoned by the English in the beginning of the fourteenth century; but in 1307, King Robert Bruce, on his way through Angus, captured, and, as was his custom in such cases, destroyed it, after putting the English to the sword.

The weekly market was held on Sundays till 1593, when an act was passed changing the market-day from Sunday to Friday. In 1661 several parties were tried for witchcraft, and some of them burnt; and the bridle or branks put upon the head at the time of execution, is still preserved. Further, it is recorded that on September 19, 1661, "Johne Kinked, pricker of the witches in Trennent, was admittit burges and frie man" of the burgh for his services at these witch trials. Alexander Strang, provost of Forfar, was the chief opponent to the betrayal of Charles I. to the English. His name is specially mentioned in *Acta Parl.*, vol. vii., p. 615. Previous to the middle of last century the town was composed of very few two-storey houses; and notwithstanding its proximity to good gray slate quar-

ries, the houses were almost all thatched. At that time beef was not sold by weight. A leg of an ox weighing five stone could have been purchased for as many shillings, and L.2 worth served the demands of the town for a fortnight. To show the domestic condition of the inhabitants at that time, it may be stated that in this royal burgh, once the seat of royalty, there were only one or two time-pieces of any kind, and none of them patent to the public; modern luxuries, or rather necessaries, were so rare, that it could boast of only seven tea-kettles, and as many hand-bellows, while peats and wood constituted the only fuel. Since the introduction of the manufacture of "Osnaburgs" (a kind of linen), about the year 1746, the trade of the town, in various branches, has progressed rapidly. Here, as in the other towns in the county, the staple trade is the linen manufacture, which employs 2900 weavers of all kinds. The number of pieces annually produced is 104,000, comprehending 13,520,000 yards, the value of which is L.260,000. The annual revenue of the burgh is L.1527, 12s. 3d., and it is gradually increasing. There are 285 electors in the burgh, which, in conjunction with Montrose, Arbroath, Brechin, and Inverbervie, sends one member to parliament. Pop. of town and parish in 1801 was 5167; in 1841 the town population was 8362, and the landward 1258; in 1851, it was in the former 9311, and in the latter 1698. (J. C—E.)

FORFEITURE originally signifies a transgression or offence against some penal law. It is an inseparable incident to felony punishable with death, and obtains to a greater or less extent of the lands of the offender, and totally in regard to his goods and chattels. The word is formed from the base Latin *forisfactura*, whence *forfaitura* and *forfaictura*, and the French *forfait*. *Forisfactura* comes from *forisfacere*, which, according to Isidore, signifies to hurt or offend, *facere contra rationem;* and is not improbably derived from *foris*, out, and *facere*, to do, an action out of rule, or contrary to the rules. Borel thinks *forfait* is derived from the using of force or violence; and Lobineau, in his glossary, supposes *forisfacta* properly to signify a mulct or amend, not a *forfeit*, which latter he derives from the Bas-Breton *forfed*, a penalty. But with us it is now more frequently used for the effect of such transgression, as the losing some right, privilege, estate, honour, office, or effects, in consequence thereof, than for the transgression itself. Forfeiture differs from confiscation in this, that the former is more general; whilst confiscation is particularly applied to such things as become forfeited to the king's exchequer; and goods confiscated are said to be such as nobody claims. See ATTAINDER, TREASON.

FORFICULA, the Earwig, a genus of coleopterous insects. See index to ENTOMOLOGY.

FORGE, a furnace where wrought iron or other metal is hammered and fashioned with the aid of heat. This is called a smith's forge. In ships a very convenient kind is the portable truck forge. Forge is also applied to the blast furnace, in which iron ore is smelted; also, where the production of the blast furnace is fused, and afterwards beaten with enormous hammers, or drawn through cylinders of different diameter, in order to render the metal soft, pure, and more malleable and ductile. Such great workshops are otherwise called *shingling mills*. See IRON-MAKING.

An ordinary smith's forge consists of the hearth or fireplace, which is merely a cavity in masonry or brick-work, lined with fire-clay or brick, and containing ignited fuel, upon which a powerful blast of air is driven through the nozzle of double-bellows, worked by a hand-lever. There are also portable forges, of small dimensions, but answering all the ordinary purposes of a smith's forge. Such are the travelling forges of armies, those used on board ships, &c.

FORGERY (from the French *forger*, signifying *accudere, fabricare*, to beat on an anvil, forge, or form), may be defined at common law to be the fraudulent making or alteration of a writing or seal, to the prejudice of another man's right; or it is the crime of imitating the subscription of another, adhibiting it to a deed, and putting that deed to use by acting under it, receiving property in virtue of it, founding on it as a title to sue or to defend, or transferring it to another. In considering forgery, it is necessary to attend, first, to the mode of proof by which the crime is established; and, secondly, to the punishment which is inflicted on the perpetrator thereof.

The proof of forgery is either direct or indirect. The direct proof consists in the examination of the writer of the deed, and of the witnesses who sign the deed and attest the subscription. As the subscription of witnesses is an attestation to which the law gives effect to the extent of receiving it on their death as evidence of the regularity of the deed, and as weight is given to the subscription of a witness, even where he does not recollect having adhibited it; so, to cut down a deed regularly attested, the instrumentary witnesses, as they are called in Scotland, must be brought to swear to circumstances of sufficient force to invalidate the evidence given by their subscriptions; a species of proof which the law does not and indeed cannot reject. The indirect mode of proof consists in an investigation of all the circumstances from which it may be inferred that the person by whom a deed is said to have been executed actually did not subscribe; as, for instance, an error in the date, an *alibi*, the stamp, the contexture of or date impressed upon the paper, or a *comparatio literarum*. The comparison of the handwriting is made with genuine subscriptions of the same date as that alleged to have been forged; and where the real subscriptions differ materially from the one founded on, the forgery of the latter may be pronounced on with a considerable degree of certainty. It is an established rule, however, that the proof of forgery by a mere comparison of handwriting is not admissible.

Until recently the punishment of forgery was not expressly laid down by statute; but by the common law and practice of the country, conviction was usually followed by a capital punishment in all cases of gross forgery; whilst those of less moment, as forgeries of executions, or where the evidence was not in every respect conclusive, were commonly visited with what in Scotland is denominated an arbitrary punishment, that is, with imprisonment or transportation. At length, however, the severity of the law in this particular was considerably mitigated, and the punishment of death restricted to the cases of forgery enumerated by the 11th Geo. IV. and 1st William IV., cap. 66. Afterwards by the 2d and 3d William IV., cap. 123, entitled an "act for abolishing the punishment of death in certain cases of forgery," it was enacted, that where any person shall thereafter be convicted of any offence whatsoever for which the previous act of William IV. enjoins or authorizes the infliction of the punishment of death, or for any offence which shall consist wholly or in part of forging or altering any writing, instrument, matter, or thing whatsoever, or of offering, uttering, or disposing of any writing, instrument, matter, or thing whatsoever, knowing the same to be forged or altered, or of falsely personating another, such offender shall not suffer death, or have sentence of death awarded against him, but shall be transported beyond the seas for the term of such offender's life. But it is at the same time specially provided that nothing in this act shall be construed to extend to the forging or altering, offering, uttering or disposing of, knowing the same to be forged or altered, any will, testament, codicil, or testamentary writing, with intent to defraud any body corporate or person whatsoever, or of forging or altering, or of uttering, knowing the same to be forged or altered, any power of attorney or other authority to transfer any share or interest in any stock, annuity, or other public fund, transferable at the Bank of England or South-Sea House, or Bank of Ireland, or to receive any

dividend payable in respect of such share or interest, with intent to defraud any body corporate or person whatsoever, or of procuring, aiding, or assisting in the commission of such offences, for all which offences the punishment of death is to continue the same as if this act had not been passed. And further, by 3d and 4th William IV., cap. 44, it is enacted, that persons punishable with transportation for life under the act of 2d and 3d William IV., shall be liable, previously to their being transported, in case the court before which they are convicted shall think fit, to be imprisoned, with or without hard labour, in the common gaol or house of correction, or to be confined in the penitentiary for any term not exceeding four years nor less than one. And, lastly, by the 7th William IV. and 1st Vict., cap. 84, the punishment of death was abolished in all cases of forgery, and the punishment substituted of transportation for life, or not less than seven years, or imprisonment for not exceeding four nor less than two years, with or without hard labour and solitary confinement, if the court think fit. As it formerly stood its excessive severity had rendered it to a certain extent inoperative; for as the natural feelings of mankind revolt at the indiscriminate sacrifice of human life for offences of a secondary description, judges and juries had tacitly combined to evade giving it effect in the less aggravated class of cases, and thus to reconcile with public opinion the practical administration of justice in this particular. From this mitigation which has taken place the efficacy of the law has been augmented by increasing the certainty of the punishment it awards; and a diminution in the number of offences of this kind resulted, which the excessive but irregular severity of the law, as it formerly stood, had failed to produce.

FORGING, in *Smithery*. See FORGE, and IRON-MAKING.

FORIS, a seaport-town of Naples, on the W. coast of the island of Ischia. It has a good harbour and some trade, and several hot springs in the vicinity. Pop. about 5000.

FORISFAMILIATION, in *Law*. When a child, upon receiving a portion from his father, or otherwise, renounces his legal title to any further share of his father's succession, he is said to be *forisfamiliated*.

FORK, a well-known instrument, consisting of a handle and a shaft terminating in two or more points or prongs. The *table-fork* did not come into use in England till the reign of James I., as we learn from a remarkable passage in Coryat, who thus solemnly relates the history of its introduction: "Here I will mention a thing that might have been spoken of before in discourse of the first Italian townes. I observed a custom in all those Italian cities and townes through the which I passed, that is not used in any other country that I saw in my travels, neither do I think any other nation of Christendome doth use it, but only Italy. The Italians, and also most strangers that are commorant in Italy, doe always at their meals use a little forke when they eat their meate; for while with their knife, which they hold in one hand, they cut the meate out of the dish, they fasten the forke, which they hold in the other hand, upon the same dish, so that whatsoever he be that sitting in the company of any others at meale shall unadvisedly touch the dish of meate with his fingers from which all the table doe cut, he will give occasion of offence unto the company as having transgressed the lawes of good manners, insomuch that for his error he shall be at least browbeaten, if not reprehended in wordes. This form of feeding, I understand, is generally used in all parts of Italy, their forkes for the most part being made of yronn, steele, and some of silver, but those are used only by gentlemen. The reason of this their curiosity is, because the Italian cannot by any means indure to have his dish touched with fingers, seeing all men's fingers are not alike cleane. Hereupon I myself thought good to imitate the Italian fashion by this forked cutting of meate, not only while I was in Italy, but also in Germany, and often times in England since I came home: being once quipped for that frequently using my fork, by a certain learned gentleman, a familiar friend of mine, Mr Lawrence Whitaker, who in his merry humour doubted not to call me a table *furcifer*, only for using a forke at feeding, but for no other cause."

FORKEL, J. NICHOLAS, a German musician and musical historian, was born at Meeder (in Saxony) in 1749. He was appointed "Director of the Music" in the University of Göttingen. His works are: *A General History of Music*, in 2 vols. 4to; *A General Biography of Musicians;* and *The Critical Musical Library*, in three vols., published at Leipzig. The best of his works is the "General History of Music," which is still considered in many parts of Germany as a standard work. He died in 1818.

FORLI, the ancient *Forum Livii*, a city of Italy, capital of a cognominal legation in the Papal States, is situated at the foot of the Apennines, in a pleasant and fertile plain, watered by the Ronco and the Montone, 38 miles S.E. of Bologna. It stands on the Æmilian way, and is surrounded by old walls, which however are of little use as a means of defence. The town is handsome and well built, and the streets are adorned with arcades. It has a fine square, a cathedral, several elegant palaces, a city hall, and other public buildings. It carries on a considerable trade in agricultural produce, and has manufactures of silk ribands and twist, oil-cloth and woollen fabrics, and wax, salt, and nitre refineries. Forli is said to have been founded by Livius Salinator after the defeat of Hasdrubal. During the middle ages it became a place of some importance; and in the fifteenth century the citadel (now used as a prison) was nobly defended by Catherine Sforza. In 1797 it was taken by the French, and made the capital of the department of the Rubicon, but in 1815 it was restored to the Pope. Pop. about 16,000.

FORLORN HOPE, in military affairs, the body of picked men guided by engineer officers, detached to lead the assault, or storm a fortress, or to perform any service attended with great danger and peril. The term is synonymous with the French *enfans perdus*.

FORM, in *Physics*, denotes the manner of being peculiar to each body; or that which constitutes it such a particular body, and distinguishes it from every other. But Mr Harris uses the term *form* in another sense, as an efficient animating principle; to which he supposes Ovid to refer in the first lines of his Metamorphoses:—

> *In nova fert animus mutatas dicere* formas
> *Corpora.*

These animating forms are not of themselves objects either of the ear or of the eye; but their nature or character is understood in this, that were they never to exert their proper energies on their proper subjects, the marble on which the sculptor exercises his art would remain for ever shapeless, and the harp from which the harper calls forth sounds would remain for ever silent.

Substantial forms seem to have been first broached by the followers of Aristotle, who thought matter, under different modes or modifications, not sufficient to constitute different bodies, but that something substantial was necessary to set them at a greater distance, and thus introduced substantial forms, on the footing of souls, which specify and distinguish animals. What led to this erroneous notion were the circumstances of life and death. For observing that, as soon as the soul had departed out of a man, all motion, respiration, nutrition, and other animal functions, immediately ceased, they concluded that these functions depended on the soul, and consequently that the soul was the form of the animal body, or that which constituted it such; indeed nobody doubted that the soul was a substance independent of matter; and hence it was concluded that the forms of other bodies were to be equally substantial. But

to this it is answered, that though the soul be that by which man is man, and consequently the form of the human body as human, yet it does not follow that it is properly the form of this body of ours, as it is a body, or of the several parts thereof, considered as distinct from one another. For those several parts have their proper forms so closely connected with their matter, that it remains inseparable therefrom long after the soul has quitted the body; thus flesh has the form of flesh, bone of bone, and so forth, long after the soul is removed, as well as before. The truth is, the body does not become incapable of performing its accustomed functions because the soul has deserted it; but the soul takes its departure because the body is no longer in a condition to perform its functions.

The ancient and modern corpuscular philosophers, therefore, with the Cartesians, exclude the notion of substantial forms, and show, by many arguments, that the form is only the *modus* or manner of the body in which it is inherent. And as there are only three primary modes of matter, figure, rest, or motion, with two others arising therefrom, magnitude and situation, the form of all bodies they hold to consist in these modes, and suppose the variations which they are capable of sufficient to present all the variety observable in bodies.

Forms are usually distinguished into *essential* and *accidental*. Though the five modes above mentioned, generally taken, be adventitious, yet to this or that body, as to fire or water, they are *essential*. Thus it is *accidental* to iron to have this or that magnitude, figure, or situation, since it might exist in different ones; yet to a knife or hammer, the figure, magnitude, and position of parts, which constitute it a hammer or knife, are essential, and they cannot exist or be conceived without these. Hence it is inferred, that though there be no substantial, yet there are essential forms, by which the several species of bodies become what they are, and are distinguished from all others. *Accidental* forms are those really inherent in bodies, but in such manner as that the body may exist in all its perfection without them; such as whiteness in a wall, heat in water, &c.

FORMALITY, as defined in the scholastic philosophy, is the manner in which a thing is conceived; or a manner in an object importing a relation to the understanding, by which it may be distinguished from another object. Thus animality and rationality are formalities. The Scotists made great use of formalities, in opposition to the virtualities of the Thomists.

FORMALITIES, in matters of law, are frequently used for the formulæ themselves, or the rules prescribed for judicial procedure. In contracts of strict law all the formalities must be strictly observed, as an omission of the least may ruin the whole convention.

FORMAN, ANDREW, archbishop of St Andrews, Earl of Pittenweem, and of Cottingham in England, one of the lords of the regency appointed by the states during the minority of King James V. of Scotland, legate *a latere*, primate of all the kingdom of Scotland, and archbishop of Bourges in France, was descended from the family of the Formans of Hutton in the county of Berwick, and is considered as having been one of the best statesmen of the age in which he lived. He was employed in 1501, along with Robert Blackader, archbishop of Glasgow, and Patrick earl of Bothwell, to negotiate a match between James IV. of Scotland and Margaret, eldest daughter of Henry VII. of England, which next year was ratified by the Scottish ambassadors. He was afterwards frequently employed as Scottish ambassador to Rome, England, and France, upon the most important occasions. In 1514 he was translated from the see of Moray, to which he had been appointed in 1502, to that of St Andrews. During the time he possessed the former, he was employed as mediator between Pope Julius II. and Louis XII. of France, who were at that time at variance; and he happily succeeded in conciliating the difference. Having taken leave of the pope, he on his return home passed through France, where he was kindly received by the king and queen, who bestowed upon him the bishopric of Bourges in France, which brought him annually 400 tuns of wine, 10,000 francs of gold, and other smaller matters. Besides this, he was most liberally rewarded by Pope Julius, who promoted him to the archbishopric of St Andrews, as has been already mentioned, conferred on him the two rich abbeys of Dunfermline and Aberbrothick, and made him his legate *a latere*. At that time, however, there were two other candidates for the archiepiscopal see. The learned Gavin Douglas, bishop of Dunkeld, having been nominated by the queen, had actually taken possession; but John Hepburn, a bold and factious man, having been preferred by the monks, drove out the officers of Gavin Douglas, and placed a strong garrison in the castle. And so great was the power of this man, that when Forman was nominated by the pope, no person could be found to proclaim the bulls for his election. At last Lord Home, at that time the most powerful nobleman in Scotland, was induced, by large promises, besides some considerable gifts, amongst which was the donation of the abbacy of Coldingham to his youngest brother David, to undertake the task. It was executed at Edinburgh and at St Andrews, to which places Lord Home's brother proceeded with 10,000 men; though the doing of it, contrary to Forman's inclination, proved a source of much trouble to that nobleman afterwards. The quarrel between Hepburn and Forman, however, was at last terminated by the latter surrendering the bishopric of Moray, as well as some years' revenue of the archbishopric itself, and paying Hepburn three thousand French crowns annually out of his ecclesiastical revenues. On the appointment of the Duke of Albany to the regency, Hepburn endeavoured to undermine the primate's credit with that nobleman, by representing him as one who had in a manner collected all the money in the country, and who consequently might endanger the tranquillity of the kingdom. These insinuations, however, were but little regarded by the regent; and Forman had the good fortune afterwards to compose a difference between him and the nobility, which was likely to be attended with bloodshed. In 1517 the archbishop was appointed by the states one of the lords of the regency, on the occasion of the Duke of Albany's going to France. His embassy to Pope Julius II. has been already mentioned. In Mackenzie's Lives we are informed, that in the collection of the Letters of the Scottish Kings from the year 1505 till the year 1626, in the Advocates' Library, there is a letter from the pope to King James IV., in which he not only commends Forman highly, but likewise promises that at the first creation of cardinals he should be made one. This letter is dated the 6th of May 1511; but the pope died before he had an opportunity of performing his promise. In the same collection there is a letter from the Duke of Albany to Leo X., successor of Julius, in which he urges the pope to advance Forman to the dignity of a cardinal, promised him by his predecessor, and to continue him as legate *a latere*. Archbishop Forman died in the year 1521, and was buried at Dunfermline. Dempster says that he wrote a book against Luther, a book concerning the Stoical philosophy, and a collection out of the Decretals.

FORMEDON, in *Law* (*breve de forma donationis*), a writ that lies for a person who has a right to lands or tenements by virtue of any entail, arising from the statute of Westminster.

FORMENTERA, the ancient *Ophiusa* or *Pityusa Minor*, one of the Balearic Islands belonging to Spain, and lying 3 miles S. of the island of Iviça. It is about 13 miles in length, by from 2 to 10 in breadth, and takes its name from the abundant crops of wheat raised in the western part,

the eastern part being chiefly covered with wood. It contains no town, and the inhabitants, amounting to about 1500, live in villages or detached cottages.

FORMIÆ (now *Mola di Gaëta*), a city of Latium, near the Via Appia, on the innermost recess of the Sinus Caietanus, or Gulf of Gaëta. It was founded very anciently by the Tyrrhenians. Some of the later poets supposed the city of Lamus, which Homer mentions, to be the same as Formiæ. At an early period Formiæ received the Roman franchise and became a municipium. Villas were built at this spot by many of the noble Romans who were attracted by the rich beauty of the surrounding country. The villa of Cicero may still be seen near Castiglione at the villa Marsana, the furthest of the three from Mola. The vine of the Formian hills produced excellent wine in the time of Horace.

FORMICA, the ANT. See index to ENTOMOLOGY.

FORMOSA (Chinese *Taewan*, i.e. *Terrace Beach*), an island lying about 90 miles off the coast of China, from which it is separated by the channel of Fo-kien. It is about 250 miles in length from N. to S., and 80 in breadth, lying between N. Lat. 22. and 25. 30., and E. Long. 120. 30. and 122. A volcanic mountain chain, rising to the height of upwards of 12,000 feet, traverses the centre of the island from N. to S., and separates the Chinese portion of it on the W. from the independent portion on the E. Some parts of the coast present bold headlands; but all the W. shore is flat and surrounded with rocks and quicksands, presenting no good harbours, with the exception of Kélung at its northern extremity. The Chinese portion of it is fertile and well watered, and possesses a very salubrious climate. Almost all grains and fruits may be produced on some part of the island, which is familiarly known as the granary of the maritime provinces of China. The rice trade alone with these provinces employs more than 300 vessels. Among its other articles of trade are maize, tobacco, sugar, fruits, timber, salt, sulphur, camphor, cotton, hemp, silk, &c. Of the eastern portion of the island little is known; the inhabitants bear no resemblance to the Chinese, but are apparently allied to the Malay or Polynesian tribes. They are of a slender form, olive complexion, wear long hair, and blacken their teeth. They have no written language, and their religion seems to be confined to a superstitious belief in demons and sorcerers. Many of the aboriginal inhabitants are still to be found on the western portion of the island, living in independent villages; others however have become incorporated with the Chinese settlers, or live in villages of their own, under the general supervision of Chinese officers.

Formosa was unknown to the Chinese till about 1403. About 1634 the Dutch established themselves here, and built Fort Zealand on a small island commanding the harbour of the capital Taewan. After retaining possession of it for 28 years, they were expelled by the famous Chinese rebel Coxinga, whose successors ruled in the island till 1683, when it was taken by the Chinese. Taewan, the capital, stands on the W. coast in N. Lat. 23. E. Long. 120. 32; but the entrance of its harbour is now choked up. The population of Formosa is estimated at from 2,000,000 to 3,000,000.

FORMULA, or FORMULARY, a rule or model, or certain terms prescribed or decreed by authority, for the form and manner of an act, instrument, proceeding, or the like.

In *Church affairs*, a profession of faith. In *Medicine*, the constitution of medicines, either with respect to their prescription or their consistence. *Chemical Formulæ* are symbols representing the different substances, simple and compound.

FORMULA, in *Mathematics*, a theorem or general rule or expression, for solving certain particular cases of some problem; so $\frac{1}{2}s + \frac{1}{2}d$ is a general formula for the greater of two quantities whose sum is s, and difference d; and $\frac{1}{2}s - \frac{1}{2}d$ is the formula or general value for the less quantity. Also $\sqrt{ax - x^2}$ is the formula or general value of the ordinate to a circle whose diameter is a and absciss x.

FORMULARY, a book or writing containing stated and prescribed forms, as of oaths, declarations, prayers, and the like; a book of precedents; a prescribed form in anything.

FORNACALIA, in *Roman Antiquity*, a festival instituted by Numa, in honour of Fornax, the goddess of ovens, at which certain cakes were offered in sacrifice. Hartung identifies Fornax with Vesta.

FORNAX, a constellation. See ASTRONOMY.

FORNIX, in *Anatomy*, a part of the *corpus callosum* in the brain, so called from its somewhat resembling a Gothic arch in shape when viewed in a particular direction.

FORRES, a royal and parliamentary burgh of Scotland, county of Moray, situated on a rising ground three miles S. of Findhorn, its port at the mouth of the river of the same name. It is a neat and well-built town, surrounded by scenery of great beauty. The great road to Inverness forms its main street, from which several smaller ones branch off. It possesses an excellent academy, called the Anderson Institution (from its founder, a private gentleman of that name), in which the classics, mathematics, natural philosophy, and other branches are taught. Besides this academy there are several private schools; also a newsroom, subscription library, and various friendly societies. Besides the parish church, there are a Free Church, and chapels for Episcopalians, United Presbyterians, and Independents. On a hill W. of the town are some remains of the ancient castle of Forres; and on another eminence in the vicinity a tower in memory of Nelson has been erected. Forres unites with Inverness, Nairn, and Fortrose, in returning a member to parliament, and is governed by a provost, three bailies, and thirteen councillors. Pop. (1851) of municipal burgh 3339, of parliamentary burgh 3468. Forres is noted for the possession of one of the most remarkable ancient stone obelisks to be found in Britain. It is thus described by Mr Cordiner, in a letter to Mr Pennant: "In the first division, underneath the Gothic ornaments at the top, are nine horses with their riders marching forth in order. In the next is a line of warriors on foot, brandishing their weapons, and in the act of shouting for the battle. The import of the attitudes in the third division is very dubious, their expression indefinite. The figures which form a square in the middle of the column are pretty complex, but distinct; four serjeants with their halberts guard a canopy, under which are placed several human heads which have belonged to the dead bodies piled up at the left of the division; one appears in the character of executioner severing the head from another body; behind him are three trumpeters sounding their trumpets, and before him two pair of combatants fighting with sword and target. A troop of horse next appears, put to flight by infantry, whose first line have bows and arrows, the three following swords and targets. In the lowermost division now visible, the horses seem to be seized by the victorious party, their riders beheaded, and the head of their chief hung in chains or placed in a frame; the others being thrown together beside the dead bodies under an arched cover. The greatest part of the other side of the obelisk, occupied by a sumptuous cross, is covered over with an uniform figure, elaborately raised, and interwoven with great mathematical exactness. Under the cross are two august personages, with some attendants, much obliterated, but evidently in an attitude of reconciliation; and if the monument was erected in memory of the peace concluded between Malcolm and Canute, upon the final retreat of the Danes, these large figures may represent the reconciled monarchs. On the edge below the fretwork are some rows of figures joined hand in hand, which may also imply the new degree of confidence and security which

took place, after the feuds were composed, which were characterized on the front of the pillar. But to whatever particular transaction it may allude, it can hardly be imagined that, in so early an age of the arts in Scotland as it must have been raised, so elaborate a performance would have been undertaken but in consequence of an event of the most general importance; it is therefore surprising that no distincter traditions of it arrived at the era when letters were known. The height of this monument (called *King Sueno's Stone*) above the ground is 23 feet, besides 12 or 15 feet under ground. Its breadth is 3 feet 10 inches by 1 foot 3 inches in thickness."

FORSKAL, Peter, a celebrated oriental traveller and naturalist, was born in Sweden in 1736. He studied at Göttingen, where he published a dissertation entitled *Dubia de Principiis Philosophiæ Recentioris*, which is considered a creditable production. Thence he returned to his own country, and in 1759 he wrote *Pensées sur la Liberté Civile*, a pamphlet which the rulers of Sweden highly disapproved of. At this time Linnæus was in the zenith of his fame; and Forskal, through his fondness for natural history, became acquainted with the great naturalist, who recommended him to Frederic V. of Denmark. Here, after obtaining the title of professor at Copenhagen, he was appointed to accompany Niebuhr in an expedition to investigate the antiquities of Arabia and Egypt. But his career was cut short by death at Jerim, July 11, 1763. Though his time was short, and his difficulties very great, yet his account of the vegetation of Egypt and Arabia is a model of the method in which such investigations should be prosecuted. His friend and companion Niebuhr was entrusted with the care of editing his MS., from which he produced a Fauna Orientalis, entitled *Descriptiones Animalium, Avium, Amphibiorum, Piscium, Insectorum, Vermium, quae in itin. orient. observavit Petrus Forskal.* 1775, 4to. In the same year appeared also an account of the plants of Arabia Felix and of Lower Egypt, under the title of *Ægyptiaco-Arabica.* This work is far in advance of those of the same nature produced by the adherents of Linnæus; and is especially remarkable as being one of the first works in which the importance of the relation of vegetation to climate is fully appreciated. By the remarkable assertion that "the specimens of plants being given, the latitude, the elevation of the surface, and the zones of vegetation upon the mountains of a country may be found," Forskal laid the foundation of geographical botany, which has proved of such interest and importance in the hands of Humboldt and other recent scientific travellers.

FORSTER, John Reinhold, a celebrated naturalist and geographer, and an accomplished scholar and linguist, born Oct. 22, 1729, at Dirschau in Polish Prussia, where his father was burgomaster or mayor. His family was of English descent, and had quitted Great Britain in the time of Charles I. At the age of fourteen he was placed for a year at the public school of Marienwerder, and was afterwards admitted into the gymnasium of Joachimsthal at Berlin, where among his schoolfellows was Pallas the celebrated naturalist. Forster applied with diligence to the study of the ancient and modern languages, and in particular of the oriental languages; and he continued the same pursuits at the university of Halle, which he entered in 1748. After three years, having completed his theological studies, he resided for two years more at Danzig, preaching as a candidate. In 1753 he obtained a small benefice at the neighbouring town of Nassenhuben; and the next year he married his cousin Elizabeth Nikolai. The expenses of his increasing family induced him to accept the proposals of the Russian consul at Danzig to superintend the establishment of the new colonies at Saratof on the Volga; but Forster, not satisfied with his success in the undertaking, in 1766 resolved to try his fortune in England, hither he proceeded well recommended but with exhausted finances. Soon afterwards, however, he received a gratuity of 100 guineas from the Russian government, and he obtained some remuneration from the booksellers for his translations from the German and the Swedish. He declined an offer of Lord Baltimore to manage his estates in America, preferring the appointment of a teacher of modern languages and natural history in the dissenting academy of Warrington. He was not, however, very popular as an instructor. In 1772 he was appointed naturalist to the expedition under the command of Captain Cook, in his second voyage of circumnavigation; and he took with him his son George, then seventeen years old. For this undertaking Forster was abundantly qualified as a man of science and an accurate observer, though his temper and conduct were not always such as to make him agreeable to his shipmates, nor was he uniformly considerate and humane in his intercourse with the uncivilized inhabitants of the countries he explored. After the return of the expedition, there were repeated disputes respecting Forster's share in the intended publication of the narrative of the voyage. Two thousand pounds, which had been granted by government for the plates of the work, were to have been equally divided between Cook and Forster for this purpose; but Forster's performance of his part of the undertaking was disapproved, and he was deprived of the advantage which he expected to have derived from the plates. He was supposed to be concerned in the account of the voyage which was published by his son; and this participation was generally considered as an infringement of the conditions of his engagement; besides that many offensive remarks and a few inaccuracies were introduced into the work. All these circumstances made Forster's residence in England by no means agreeable, and his pecuniary embarrassments became so pressing that he was at one time in confinement for debt. He was, however, set at liberty in 1780, by the munificence of the king of Prussia, who paid his debts and established him at Halle as professor of natural history, and inspector of the botanical garden. The following year he took the decree of M.D. in the university. He was not always on the most cordial terms with his academical colleagues, and his circumstances were also much embarrassed by his unfortunate propensity to play, which absorbed his whole earnings. The premature death of his two sons seriously affected his health, and he died on the 9th December 1798. His life has been written by Professor Kurt Sprengel, but in a manner somewhat too flattering with regard to Forster's moral character. He appears to have been master of seventeen languages; and he was as extensively acquainted with things as with words, being as much indebted for his various knowledge to his industrious and accurate observation of nature, as to his great reading and his profound learning. He was long intimate with Buffon, and was in constant correspondence with Linnæus and his son, the latter of whom gave the name of *Forstera* to a new genus of plants. In conversation he was witty, but too satirical; and his unguarded sallies created him many enemies. He became a fellow of the Society of Antiquaries soon after his arrival in England; in Feb. 1772 was elected a fellow of the Royal Society; and in 1775 he received the honorary diploma of LL.D. from the university of Oxford.

His principal publications are as follows:—*Specimen Historiæ Naturalis Volgensis, Phil. Trans.* 1767, p. 312, containing a description of the country about Saratov. *An Introduction to Mineralogy*, 8vo, Lond. 1768; with a *Translation of* Lehmann's *Halotechnia. A Catalogue of British Insects*, 8vo, Warrington, 1770. *A Translation of* Kalm's *Travels into North America*, 3 vols. 8vo, Warrington and Lond., 1770, 1771. Osbeck's *Voyage to China and the East Indies, translated from the German; with a Faunula and Flora Sinensis*, 2 vols. 8vo, Lond. 1771. *A Translation of* Bossu's *Travels in Louisiana, with Notes, and a Systematic Catalogue of all the known Plants of English North America; together with an Abstract of* Löfling's *Travels*, 2 vols. 8vo, Lond. 1771. *Novæ Species Insectorum*, Centuria 1, 8vo, Lond. 1771; consisting chiefly of English insects. *An Account*

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of the management of Carp in Polish Prussia, Phil. Trans. 1771, p. 310. *An Easy Method of Assaying and Classing Mineral Substances, with a Translation of* Scheele's *Experiments on Sparry Fluor*, 8vo, Lond. 1772. *Translation of* Bougainville's *Voyage*, 4to, Lond. 1772. *Epistolæ ad* J. D. Michaelis, 4to, Gottin. 1772, containing remarks on this author's *Spicilegium Geographiæ Exteræ. An Account of the Roots used by the Indians in the neighbourhood of Hudson's Bay to dye Porcupines' Quills, Phil. Trans.* 1772, p. 54; the Galium tinctorium and Helleborus trifolius. *An Account of Several Quadrupeds from Hudson's Bay, Phil. Trans.* 1772, p. 370. *An Account of the Birds sent from Hudson's Bay*, p. 382. *An Account of some Curious Fishes sent from Hudson's Bay, Phil. Trans.* 1773, p. 149. Translation of Grainger's *Travels* and Riedesel's *Travels. Catalogue of the Animals and Plants represented in Catesby's Carolina, with the Linnæan names. Characteres generum plantarum, quas in itinere ad insulas maris australis collegerunt* J. R. et G. Forster, fol. Lond. 1776, containing descriptions and figures of 75 new genera. *Liber singularis, de Bysso antiquorum, quo ex Ægyptiaca lingua res vestiaria antiquorum*, 8vo, Lond. 1776. The object of this essay is to prove that the *byssus* of the ancients was cotton, not linen. *Observations made during a Voyage Round the World, on Physical Geography, Natural History, and Ethic Philosophy*, 4to, Lond. 1778. A French translation of this interesting work was added as a fifth volume to that of Cook's Voyage, 4to, Paris, 1778. *Description of the Yerbua Capensis, Swed. Trans.* 1778, p. 108. *Translation of* Von Troil's *Letters on Iceland*, 8vo, Lond. 1780. *On* Buffon's *Epochs of Nature, Göttin. Mag.* 1780, i. i. p. 140. *On the Tiger-Cat of the Cape, Phil. Trans.* 1781, p. 1; the Felis Capensis, found from Congo to the Cape, and capable of being tamed like a cat. *Historia Aptenodytæ, Commentat. Göttin.* vol. iii., p. 121. *Zoologia Indica Selecta*, Latin and German, fol. Halle, 1781, 4to, Lond. 1790; 2d edit. Halle, 1795. *Account of a New Insect, Naturforscher*, vol. xvii. p. 206, Halle, 1782; a species of cancer. *A Picture of England for* 1780, *continued to* 1783, 8vo, 1784; German, 8vo, Dessau, 1784; giving some particulars of many of the principal public characters at the time of the American war. *Essays on Moral and Physical Geography*, 3 vols. 8vo, Leips. 1781, 1783; continued by his son-in-law Matthias Sprengel. *A Collection of Memoirs relating to Domestic Economy and Technology*, 8vo, Halle, 1784. *On the Albatross, Mém. Sav. Etr.* vol. x. p. 563; the Diomedea. *History of Discoveries and Voyages in the North*, 8vo, Francfort on the Oder, 1784; English, Lond. 1786, Fr. Paris, 1788. *Project for abolishing Mendicity, especially at Halle*, 8vo, Halle, 1786. *Enchiridion Historiæ Naturali inserviens*, 8vo, Halle, 1788. *A Memoir on the Badjer Cit. Mém. Acad. Berl.* 1788, 1789, p. 90; the Manis pentadactylus. *Magazine of Modern Voyages and Travels, translated from various Languages, with Remarks*, 16 vols. 8vo, Halle, 1790, 1798. An edition of *Bergius über die Leckereyen*, a work on diet, with notes by Forster, Kurt, and Sprengel, 2 vols. 8vo, Halle, 1792. *A Letter to Schreber on the Persea, Magazin für die Botanik*, vol. v. p. 234. *Onomatologia nova systematis oryctognosiæ vocabulis Latinis expressa*, fol. Halle, 1795, 1 page. *Observations and Truths united to Probabilities, or Materials for a new Essay on the Theory of the Earth*, 8vo, Leipz. 1798.

(Sprengel's *Memoir*; Eyries in *Biographie Universelle*, vol. xv. 8vo, Paris, 1816; Aikin's *General Biography*, vol. iv. 4to, Lond. 1803; Chalmers's *Biographical Dictionary*, vol. xiii. 8vo, Lond. 1814.) (T.Y.)

FORSTER, JOHN GEORGE ADAM, commonly called GEORGE, a distinguished naturalist and circumnavigator, the son of John Reinhold Forster, was born at Danzig in 1754, and enjoyed, in his earliest youth, the advantage of his father's assiduous and affectionate instructions, by which he profited so rapidly, that he was capable, at the age of ten years, when he went with his father into Russia, of ascertaining the species of a plant by comparing it with the Linnæan description. He was for a short time at a school in Petersburg. Upon his arrival in London, he was at first placed in a merchant's counting-house, but soon found his health unequal to the employment, and followed his father to Warrington, where he continued his studies at the academy with so much application, that he became a perfect master of the English language, and otherwise distinguished himself by the strength of his memory and the vigour of his imagination, at the same time that he assisted his father in giving lessons in French, and in completing a variety of translations of voyages and travels. He also accompanied his father, together with Sparrman, in the arduous engagement of making all kinds of physical observations in the circumnavigation of the globe; and he was particularly employed in delineating the various objects of natural history which were discovered. After his return he was elected a fellow of the Royal Society; but he soon quitted England to settle at Paris. In 1779, however, he was appointed professor of natural history at Cassel; and in 1784 he was nominated to a similar situation in the university of Wilna, where he took a degree of doctor of physic; but he found little satisfaction in residing amongst a people so imperfectly civilized. The Empress of Russia had engaged him to take an important part in a new voyage of discovery which she meditated; but the design was abandoned upon the commencement of the war with the Turks. He was next invited by the Elector of Mentz to accept the appointment of president of the university newly established in that city, and he was residing there at the time when the French army entered it. Being a declared republican in his political principles, he was despatched as an envoy to Paris to solicit the incorporation of Mentz with the French republic; but during his absence the Prussian troops retook the city, and he lost the whole of his property, including his numerous manuscripts. He had married a Miss Theresa Hayne, and had one daughter as early as 1788; but, at a subsequent period, his wife's conduct gave him great reason for uneasiness; and though he affected to despise what he called the prejudices of social life, and to excuse her infidelity, and even attempted to facilitate her union with a more favoured admirer, still the affair in reality affected him deeply, and he resolved once more to leave Europe, as if in search of the waters of oblivion; and he was actually preparing for a voyage to Thibet, when his health was subdued by the ravages of a scorbutic disorder, and he died on the 13th February 1792. Besides the assistance which he rendered his father in many of his literary undertakings, he was also the author of a variety of separate publications under his own name.

Forster.

1. *A Voyage Round the World in his Britannic Majesty's Ship Resolution, commanded by* Captain James Cook, *during the years* 1772, 1773, 1774, and 1775, 2 vols. 4to, London, 1777; in German, 2 vols. 4to, Berlin, 1779, 1780, and 3 vols. 8vo, 1784. The style of this work is rather more animated and poetical than that of the official account of the voyage; the second volume is considered as the best written, and the freest from affectation and false sentiment. 2. Mr Wales, the astronomer of the expedition, published some remarks on the work, which occasioned a *Reply to* Mr Wales's *Remarks*, 8vo, London, 1778, in which the author declares that his father had no concern whatever in the book, but he admits that he had committed some inaccuracies. 3. *A Letter to the Earl of Sandwich*, 4to, London, 1779. 4. His *Answer to the Authors of the Literary Journal of Göttingen* exhibits considerable warmth of language, but candidly admits some errors; it excited some further animadversions from Professor Meiners, who declared himself the author of the criticisms. 5. In 1787 he published at Berlin, in 4to, *A Translation of Captain Cook's Third Voyage, performed in* 1776–1780, with an introduction and other additions. 6. *A Description of the Gentiana saxosa, Swedish Trans.* 1777, p. 183. 7. *Life of Dr Dodd*, 8vo, Berlin, 1779. 8. *Preface to Sparrman's Travels*, 8vo, Berlin, 1784. 9. He undertook, together with Professor Lichtenberg, the publication of the *Göttingen Magazine*, which was continued from 1780 to 1785, and published in it, amongst other essays, *A Description of the Red Creeper, or Certhia coccinea of Owhyhee*, i. vi., p. 346. 10. *Experiments with Vital Air*, vol. iii., ii., p. 281; examining its effects on glow-worms. 11. *A Decade of New Plants*, N. Act. Upsal, vol. iii., 1780, p. 171. 12. *On Pygmies*, Hessiche Beyträge, vol. i., p. 1, 1785. 13. *History and Description of the Bread-Fruit Tree*, p. 208, 384; also separately, 4to, Cassel, 1784. 14. *Florulæ Insularum Australium Prodromus*, 8vo, Göttingen, 1786. 15. *Vasculus Plantarum Magellanicarum*, Commentat. Soc. Gött., vol. ix., p. 13. 16. *Plantæ Atlanticæ*, p. 46. 17. *Miscellanies, or Essays on Moral and Physical Geography, Natural History, and Moral Philosophy*, 6 vols. 8vo, Leipsic and Berlin, 1789–1797; the last two volumes are posthumous, and chiefly of a political nature. 18. *Picture of the Lower Rhine, Brabant, Flanders, Holland, England, and France*, taken in the year 1790, 3 vols. 8vo, Berlin, 1791–1794; Dutch, Haarlem, 1792, 1793; French, called *Voyage Philosophique*, 2 vols. 8vo, Paris, 1795, 1796. This work contains many interesting remarks on manners and on the arts, showing that the author possessed very extensive information, as well as originality of talent; but there is too much affectation of sentiment, and an injudicious display of hostility to Great Britain. 19. *Historical Remembrances*

of the Year 1790, 8vo, Berlin, 1793. There are also several political pamphlets of a temporary nature, which could add little or nothing to their author's fame; and a few scattered memoirs in different periodical publications. He was also concerned in the *Collection of Voyages* published by Professor Sprengel; and, together with Pallas and others, in an edition of Martini's *Dictionary of Natural History*. Indeed, his life, though short, was one continued scene of literary activity; but his application to the labour of compilation was too unremitting to allow him to concentrate the whole force of his mind on the performance of any one great original work of genius. The *Sketches of the Mythology and Customs of the Hindoos* were written by another author of the same name.

(*Life* by Pougens; J. R. Forster in *Jacobi's Annals*, and in the *Dedication of his Enchiridion;* Eyries in *Biographie Universelle*, vol. xv., 8vo, Paris, 1816; Aikin's *General Biography*, vol. iv., 4to, London, 1808; Chalmers's *Biographical Dictionary*, vol. xiii., 8vo, London, 1814.) (T. Y.)

FORT, a small fortified place, environed with a ditch, rampart, and parapet. The use of forts is to secure some high ground, or the passage of a river, to make good an advantageous post; to defend the lines and quarters of a siege, and the like. Forts are built of different figures and dimensions, according to the exigencies of the case. Some are provided with bastions, others with demi-bastions; some are of a square form, others pentagonal, and others again are stellated, having five or seven angles. See FORTIFICATION.

Vitrified FORTS. This name has been given to certain remarkable ruins, situated for the most part on the tops of certain hills in the Highlands and northern parts of Scotland. They were first described, about the year 1773, by Mr Williams, an intelligent mineral surveyor. These singular structures derive their appellation of vitrified from the circumstance of the stones composing them presenting the appearance of having been melted or fused by means of fire; thus forming a solid mass of a glassy structure, somewhat resembling volcanic lava, or the refuse of a furnace. In form, size, and situation, they present every variety. Some of them are round or elliptical, whilst others are in the form of squares or parallelograms. In magnitude they vary from a few yards to some eighty or ninety in length, whilst their breadth differs in a proportional degree. The walls likewise vary much in thickness. Some of them are only two or three, and others are about twenty feet in breadth. In height they also differ considerably, having apparently in some instances been twelve feet, and in others not a third of that height. In one or two instances there are a series of walls, two or three in number, inclosing the same area of ground, with a space between each of the works sufficiently large to admit of active defensive operations on the part of those who occupied the place. Their vitrification is very irregular. Occasionally it does not extend a few feet above the ground on which the fabric stands, nor penetrate beyond the surface, whilst in a few instances it rises to the height of ten or twelve feet, and passes inwards to a considerable extent on both sides; and sometimes only isolated parts of the walls show traces of vitrification. They generally occupy commanding positions; but are also found on the sea-shore, and sometimes many miles inland. In general their structure displays nothing like regular masonry. A few of them are approached by regular causeways; and many are furnished with wells, an indispensable requisite for a garrison.

After the publication of Mr Williams's account, the ingenuity of the learned was turned to their probable origin, and many ingenious theories were hazarded on the subject. Some declared them to be of volcanic origin, whilst others contended that they were works of art. The most probable conjecture respecting the vitrification of these structures appears to be, that the ancient inhabitants of Britain, who were unacquainted with the use of mortar, discovered, probably by accident, that some rocks which resist the action of fire become fusible when subjected to a high temperature in contact with certain others; and that the knowledge of this fact led them to employ masses of such mixed rocks in their structures, the stones of which were then cemented together or *vitrified*, by heaping combustibles about them and setting them on fire.

Vitrified remains are of very frequent occurrence in Scotland, more particularly in the northern and north-western counties. Many of these have been minutely described in various works, to some of which we shall presently refer, and in this place shall merely give an account of one or two of the more remarkable of such remains, in order to illustrate their general character.

Dun MacSniochain, which lies in Argyleshire, is thus described by Dr Macculloch.[1] "It is situated on a small rocky hill, which forms a kind of island in the plain, of a narrow prolonged shape, and scarped all round, except at one extremity, which affords access to the summit and the fort. The height of this hill or rock above the plain seems to be about forty or fifty feet; and it is, even in the modern military sense, a strong position. It is important to remark, that the rock consists of limestone and slate intermixed, the plain itself being chiefly alluvial, and the nearest hill and rocks being of trap, and of that pudding-stone so well known to all travellers, which also abounds in the vicinity of Oban. That stone is itself formed of fragments of various trap rocks, and is remarkable for its ready fusibility, while the rock on which the fort stands is of an infusible nature. The fort itself is so contrived as to occupy nearly the whole summit, which is about 250 yards long, and consists of three distinct parallelogramic enclosures. The dimensions of these are as follows, as nearly as could be measured by pacing. The outer is about thirty yards long and about twenty-four broad; the next is about thirty-seven, with a similar breadth; and that at the further extremity is about fifty-six yards in length, but being imperfect, it may formerly have been longer. Besides this, between the first and second works there is a transverse wall which reaches from the one precipitous face to the other, so as, when entire, to have cut off the communication from without to the two inner works. The circumferences of the two inner enclosures make collectively a line of about 260 yards, which, according to the modern military computation for a redoubt, would contain more than 500 men. The external work would dispose of about a hundred more. Hence it is plain that this must have been a military work of some consequence, as capable of holding a large garrison." He continues, "when it is said that the walls here or elsewhere are vitrified, it must not be supposed that they form a solid mass of glass or slag. That condition is very various in different specimens throughout Scotland, and if it is here more perfect than in many, it is less so than in some others. To speak more accurately, many of the stones which form the walls are more or less perfectly slagged or scorified; so that while some have been thus changed throughout, the surfaces only of others are affected, while others again, consisting of less fusible materials, are only burnt. A certain proportion has escaped the fire altogether, or has never been exposed to it; and if we may judge from the ruins, this has taken place chiefly towards the upper part of the wall. The general result, however, is, that in some parts the wall forms a solid mass, but of an irregular composition, consisting of scoria, slag, burnt stones, and stones scarcely altered, united together, but with vacant intervals; while in other places it is separable into lumps of various sizes, and into single stones."

That of Dunadeer is described as follows:—

"The hill of Dunadeer, having an elevation of about 600 feet[2] from the irregular plain on which it stands, with

[1] Macculloch's *Highlands and Western Isles*, vol. i., p. 283.

[2] This is an exaggeration; it is only about 400 feet high at the most.

a steep acclivity all round, has a flat oval summit, which is entirely occupied by the enclosure, so as to form a strong military position. Though much ruined, and consequently obscured, having apparently been used as a quarry for building a more modern castle in the same spot, it is not difficult to trace either the dimensions or the disposition of the original work. The form is a parallelogram, of which one extremity is curved, so as to be nearly semicircular, and its longest side is about fifty-eight yards, the shortest being about twenty-four. The thickness of the wall seems originally to have been eighteen or twenty feet; although, from the state and nature of the ruin, it is impossible to be very accurate in this particular. The highest remaining portion is about six feet above the present surface; and if one foot be added for the increase of soil, and two for the loss which it has sustained at the summit, to be computed from the ruined part at its foot on each side, we shall have eight feet as the probable original altitude.

"The materials of the hill are chiefly gray granite, an infusible rock; but there are scattered in the surrounding plain blocks of a black variety, which, from containing hornblende, is very fusible. To pass over the obviously more modern ruins at this place,[1] as not concerning the present question, there are at a certain stage down the hill the well-marked traces of a work which once seems to have encircled the whole. It is a kind of fortification well known to antiquaries as occurring frequently in the ancient British hill forts; and it resembles a modern military field work, as it consists of a single ditch and wall, the latter being formed of loose stones not vitrified. I consider this as part of the original defences, because a similar one is found on Noath.

"The materials in the vitrified wall are, as at Dun MacSniochain, partly roasted without adhesion, and partly vitrified, or glazed or scorified, in a similar manner. It is easy to see that the dark granite forms the vitrified and scorified substances; but, not to enter on the more minute details, which rather concern the chemist and mineralogist than the antiquary, but which are very interesting to them, I shall only further remark, that wherever stones not capable of vitrification themselves have undergone this change, it has been produced by the alkali of the wood used in the process; whence the glazed surfaces of many unvitrifiable substances.

"Now I remarked that at Dun MacSniochain the materials of the hill itself were not vitrifiable, but that a very fusible rock was present at a short distance, or scattered in fragments about the plain. The same is true here; and in both cases the forts are not erected out of the materials nearest at hand, which are infusible, but collected with considerable labour from a distance. It is hence evident that the builders of those works were aware of the qualities of these various rocks, and it is equally evident that they chose the fusible in preference to the infusible, although with a considerable increase of labour."

Among other vitrified forts more particularly deserving of notice, may be mentioned that upon the hill of Noath in Aberdeenshire; and the large one on the hill of Knockfarril, two miles west of Dingwall in Ross-shire.

Another of these forts is situated about a mile from Inverness, upon the hill of Craig-Phadrick (or Rock of Peter) at the eastern end of the Great Glen, and forming the termination of the high sandstone and conglomerate hills of Loch Ness. Craig-Phadrick is about 435 feet in height above the sea. The summit presents two vitrified walls quite round the area. The space within the inner wall is 80 yards long and 30 broad. It is now overgrown with wood and moss; but in 1812, when the late Mr Telford was engaged in the construction of the Highland roads and bridges, the interior was cleared out, and the vitrification minutely examined. Both the outer and inner ramparts are chiefly composed of a reddish coloured schistus, which seems to have been taken from the south-west end of the fort, where there is an opening that had apparently been occupied by this species of rock up to the common surface. The pieces of stone composing the walls are none of them large. They have been laid down without any order or regularity, and so carried up in this manner to within about two feet of the present top, where a stratum or crowning of small fragments of pudding-stone or conglomerate has been laid on, and by some means brought into a state of vitrification. The great mass of schistus composing the ramparts is quite loose and not vitrified, but nearly the whole of it bears evident marks of having been exposed to a considerable degree of heat, as appears from its yellowish red or brick colour. In the north-west ramparts, especially the outer one, the vitrification is wanting for a considerable space, but the remaining schistus bears all the marks of that found under the vitrification. The most practical-looking conjecture is that over the wall of schistus work was placed a thick layer of timber, faggots of furze or heath, and then a stratum of conglomerate stones laid over all, when the timber, &c., being set on fire would produce the desired vitrification, and give to the lower work the scorched appearance it possesses. Seaware, of which there is abundance at hand, may have been used as a flux. The principal entrance into the fort appears to have been at the north-east end, which was defended by the strongest ramparts, and by a deep trench. The passage over the trench is by a solid dyke composed of similar materials to the ramparts. The entrance at the south-west end is not so well defined, the top of the inner rampart there being nearly as high as the adjacent parts. The chasm or passage through the rock below the outer rampart to the deep hollow which separates Craig-Phadrick from the chain of mountains on the south-west appears to be natural, not artificial, as was conjectured by the late Mr Tytler of Woodhouselee. Such appearances are not uncommon. The four stones or boulders lying on the rocky platform near the brink of this passage are certainly fragments of a larger rock that must once have occupied the platform, and were not placed there, as Mr Tytler supposed, to stop the progress of an invading army. The largest of the boulders is about 10 or 11 tons weight, and a whole regiment might have passed before it could have been put in motion by manual labour, while the other stones are too small to have given any serious obstruction to an enemy. It has been stated that there is a well of about 6 feet in diameter at the summit of Craig-Phadrick, in the centre of the inner area, but this is a mistake. There is no water nearer than a spring about 300 feet perpendicular below the summit of the hill. From the scarcity of water and the want of room, cattle could not have been admitted for any length of time into the fort, and it is probable that at the date of these erections the principal animal food of the people was that procured by the chase and hunting in the forests. The theory that the vitrified forts were merely beacons to warn the country of approaching invasion, seems inadmissible. The circular ramparts and vitrification are too regular to guarantee this supposition. They may, however, have been used in the middle ages as sites for alarm fires; and Craig-Phadrick is within sight of a chain of similarly vitrified structures communicating over the country; but there are others (in Nairnshire for example) which could not have answered for this purpose. They are much more likely to have been the fortified residences of petty chiefs at a period before the use of lime cement was known in the north of Scotland—perhaps ages before the Scandinavians

[1] **This, we presume, refers to the remains of an oblong tower constructed of lime, mortar, stone, and fragments of the earlier vitrified fort, to which the opponents of Dr Macculloch ascribe a more modern date than belongs to the rest of the structure.**

were possessed of knowledge requisite for equipping fleets powerful enough to give much disturbance to their southern neighbours. The baronial castles and forts of the middle ages are frequently found in situations nearly as inconvenient for domestic comforts as the more ancient vitrified forts.

In the parish of Meigle, Perthshire, there is a hill called Barryhill, which appears to have been strongly fortified, though without any attempt at cementing stones; but at the south-east extremity of the fort there was a vitrified mass in the form of a wall or dyke occupying the bottom of the trench between the summit and the outer rampart.

Near Creich, in the county of Sutherland, there are some vitrified remains; as also near the church of Amwoth, in the county of Kirkcudbright; and in the island of Bute, in the parish of Kingarth, there is a vitrified fort. In Cantyre, at the entrance of the bay of Carradale, on a small island, about a rood of ground is enclosed by vitrified masses, Others have been observed in Argyleshire, particularly one on the hill of Dunskeig, which commands the entrance of Loch Tarbert.

On the hill of Laws, near the village of Sturdymuir, a few miles north-east from Dundee, there is a vitrified fort. About four miles east from Forfar is the castle-hill of Finhaven, the vitrifications on which have been compared by Dr Anderson to the effects of fire in a limekiln.

It is impossible in this place to point out all the vitrified ruins, amounting to about fifty, and extending over Perthshire, Forfarshire, Kincardineshire, Aberdeenshire, Banffshire, Morayshire, Inverness-shire, which contains an immense number, Ross-shire, Cromartyshire, Argyleshire, Buteshire, Berwickshire, and Galloway. Dr Hibbert, in a paper read to the Society of Antiquaries of Scotland in 1831, informs us that he had discovered masses of vitrified matter at Elsness in Sanday, one of the Orkney islands. Of these curious remains, which he calls vitrified cairns, or beacon cairns, he counted more than twenty. They are of a round shape, from three to five yards in diameter, and elevated from two to three feet above the surface of the ground. The stony fragments of which they are composed appear to have been collected from the beach, and consist of an argillaceous schist. Their fusibility they derive chiefly from the feldspar, or rather the alkali, which they contain. For further information respecting vitrified forts and similar remains of antiquity, see Macculloch's *Highlands and Western Isles; Archæologia Scotica; Transactions of the Society of Antiquaries of Scotland*, vol. iv., &c. &c.

FORT-AUGUSTUS, FORT-GEORGE, and FORT-WILLIAM. See Inverness-shire.

FORT ST DAVID, a town of Hindostan, on the sea-coast of the Carnatic, situated on the river Tripapolore. Three rivers of considerable size all fall into the sea in the space of four miles within the bounds of Fort St David. The Panaur is about 1800 yards to the north of the Tripapolore, and the two streams communicate by a canal which runs parallel to the margin of the sea, from which it is distant about 1000 yards. Fort St David stands in the angle formed by the junction of the canal with the Tripapolore, which passes close to the site of the fort, and then sends to the south an arm that joins at no great distance the river of Bandapollam, where both in one channel continue along the eastern side of Cuddalore, separated from the sea by a mound of sand. This factory was first established in the year 1691. After the capture of Madras by the French in 1746, the English were besieged here without success; and from this period it continued the head of the English settlements till 1758, when it was taken by Lally after a short siege, and the fortifications were destroyed. It is 100 miles S.S.W. from Madras, and 15 S.S.W. from Pondicherry. Long 79. 50. E., Lat. 11. 46. N.

FORTALICE, the name given in Scotland in former times to a small place of strength, built for the defence of the country, and which on that account was considered as belonging to the king, and consequently did not go along with the lands upon which it was situated without a special grant from the crown. Now, fortalices go as part and pertinent of the lands.

FORTAVENTURA, or Fuerteventura, one of the Canary Islands. See Canary Islands, vol. vi., 167.

FORTESCUE, Sir John, an eminent English lawyer in the reign of Henry VI., was descended from an ancient family in Devonshire, though both the time and place of his birth are unknown. He is supposed to have been educated at Oxford, and the great learning displayed in his writings does no discredit to such a supposition; but it is nevertheless altogether uncertain at which university he studied, or whether he ever studied at any. When he turned his views to the legal profession he entered himself of Lincoln's Inn, where he soon distinguished himself by his knowledge of the civil as well as of the common law. In the fourth year of Henry VI. he was appointed one of the governors of Lincoln's Inn, and three years afterwards the same office was again conferred upon him. In 1441 he was made a king's serjeant at law, and the following year chief justice of the King's Bench. As a judge Fortescue is highly commended for his wisdom, gravity, and uprightness; and he seems to have enjoyed great favour with the king, who is said to have given him some substantial proofs of esteem and regard. He held his office during the remainder of the reign of Henry VI., to whom he steadily adhered; and having faithfully served that unfortunate monarch in all his troubles, he was attainted of treason in the first parliament of Edward IV., which assembled at Westminster in November 1461; having been included in the same act by which Henry VI., Margaret of Anjou his queen, Edward their son, and many persons of the first distinction, were likewise attainted. When Henry subsequently fled into Scotland, he is supposed to have appointed Fortescue, who appears to have accompanied him in his flight, chancellor of England; and although the name of the latter is not found recorded in the patent rolls, because, as Selden remarks, "being with Henry VI. driven into Scotland by the fortune of the wars with the house of York, he was made chancellor of England while he was there," yet several writers have mentioned him by this style and title; and in his book *De Laudibus Legum Angliæ*, he calls himself *Cancellarius Angliæ*, which seems to settle the question. Early in 1463, Fortescue embarked at Bamberg with Queen Margaret, Prince Edward her son, and many other persons of distinction who followed the fortunes of the house of Lancaster, and landed at Helvoetsluys, from which the party were conducted by Bruges and Lisle to Lorraine. Being thus expatriated, he remained many years on the Continent, moving about from place to place, as the necessities of the royal exiles required, and endeavouring to promote their interest by every means in his power. But his most important labours during this period were of a different and more lasting kind. Having observed that Prince Edward applied himself wholly to military exercises, and seemed to think of nothing but qualifying himself to command in battle, Fortescue, who had observed in him indications of a sound understanding, judged it high time to endeavour to give him other impressions, and particularly to infuse into his mind just notions of the constitution of his country, as well as a due regard for its laws. With this view he drew up his celebrated work *De Laudibus Legum Angliæ*, which, though it failed of its primary intention, owing to the barbarous murder of the young prince for whose benefit it was composed, will yet remain a lasting monument of the author's learning and patriotism. When the prospects of the exiles began to brighten a little, the queen and the prince returned to England, accompanied by Fortescue and others, who no doubt hoped that a more

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auspicious day was about to dawn upon the descendant of time-honoured Lancaster. But destiny still counter-worked the designs of the heroic Margaret. Her attempt to assert the rights of her son totally failed; and the chancellor, forced to reconcile himself as he best could to the victorious Edward IV., wrote an apology for his conduct, which, though Selden had seen it, has never been published. Little further is known respecting the life of this remarkable man, excepting that, amidst all the changes of masters and varieties of fortune, he steadfastly maintained those constitutional principles which he had with equal ability and conciseness explained in the celebrated treatise above referred to. He appears to have died at a very advanced age, though the time of his death, like the date of his birth, has not been ascertained.

Fortescue's masterly vindication of the laws of England, though received with great favour by the learned of the profession to whom it was communicated, did not appear in print until the reign of Henry VIII., when it was published by Whitechurch in 16mo, but without a date. In 1516 it was translated by Mulcaster, and printed by Tottel; and again in 1567, 1573, and 1575, and also by White in 1598, 1599, and 1609. It was likewise printed, with Hengham's *Summa Magna et Parva*, in 1616 and 1660, 12mo; and again with Selden's notes in 1672, in 12mo. In 1737 it appeared in folio; and, in 1775, an English translation, with the original Latin, and Selden's notes, besides a variety of remarks relative to the history, antiquities, and laws of England, was published in 8vo. Waterhouse's *Fortescue Illustratus*, which appeared in 1663, hough prolix and defective in style, may be consulted with advantage, and will serve to facilitate the labours of more judicious and able inquirers. 2. Another valuable and learned work by the same author, but written in English, was published in the reign of Queen Anne, under the title of The Difference between an absolute and limited Monarchy, as it more particularly regards the English Constitution, and accompanied with some remarks by John Fortescue Aland of the Inner Temple, London, 1714, in 8vo; and a second edition with amendments appeared in 1719, 8vo. In the Cotton Library there is a manuscript of this work, in the title of which it is said to have been addressed to Henry VI.: but many passages show plainly that it was written in favour of Edward IV. 3. Of the author's other writings, which were pretty numerous, but never printed, we know nothing more than can be collected from the titles, and the commendations bestowed on them by persons who had perused the manuscripts. Those still extant are, 1. *Opusculum de Natura Legis Naturæ, et de ejus censura in successione Regnorum Supremorum;* 2. *Defensio juris Domus Lancastriæ:* 3. Genealogy of the House of Lancaster; 4. Of the Title of the House of York; 5. *Genealogiæ Regum Scotiæ;* 6. A Dialogue between Understanding and Faith; 7. A Prayer Book which savours much of the Times we live in; with some others, which, as the author was a man of great knowledge and observation, will, we trust, yet be printed. When lord-chancellor, Fortescue is said to have drawn up the statute of the 28th Henry VI. on the resumption of certain grants of the crown, which, though much relied on by writers on that subject, is not extant in any edition of the statutes. (J. B—E.)

Length, breadth, and depth.

FORTH, one of the largest rivers in Scotland. It is first formed of several small streams rising on the north of Ben Lomond, or flowing from Loch Katrine and the other lakes in the adjacent country. It proceeds easterly in a direct course for above 100 miles, receiving in its progress the tributary waters of the Goodie, the Teith, and the Allan above Stirling, and below it the Devon, the Carron, the Avon, the Almond, the Leith, the Esk, the Leven, the Tyne, and others; and it discharges itself into the German Ocean in about 56. 10. of north latitude. The windings of the Forth, both above and below Stirling, are extremely beautiful. From its junction with the Teith above Stirling to the carse ground below Gartmore the windings extend about 28 miles, although the distance in a direct line is only about 20. From Stirling harbour to Alloa the length of the river is $10\frac{1}{2}$ miles, although in a straight line it is not more than 5, and here it is comparatively narrow, shallow, and winding. From Alloa to Grangemouth the distance is 5 miles; and here the Forth widens, with a variable depth of from 4 to 15 feet at low water. From Grangemouth to the Long Craig Beacon at North Queensferry, a distance of 10 nautical miles, proceeding downwards the depth increases in the first mile from 10 to 15 feet, and in the second mile to 25 feet at low water, and at the third mile to 53 feet, while the remaining part of the distance—7 miles, including the great anchorage of St Margaret's Hope—has a depth generally of about 60 feet at low water. At Queensferry the river is 2 miles wide; at Kinghorn nearly 6; between Dysart and Aberlady about 12; and between St Abb's Head and Fifeness, where the Forth joins the German Ocean, it is from 35 to 40 miles. Near Queensferry, between Inchgarvey and the north shore, it deepens to 37 fathoms. Between Elie and the south shore its depth is sometimes 30 fathoms; and it never exceeds this depth to the westward of its junction with the north sea, except as above stated.

Tides.

The Forth, like other streams connected with the ocean, ebbs and flows twice in 24 hours, but the flood and ebb run about two hours longer in the middle than at the shore. The tide flows $4\frac{1}{2}$ miles above Stirling shore. At this harbour spring tides rise 7 feet 9 inches, and at Alloa $19\frac{1}{2}$ feet.

It was high water, according to Captain Thomas's observations in 1815, at

	H. M.	Spring Tides rise	Neap Tides rise
Elie Harbour	2.11 p.m.	14 feet.	6 feet.
Leith and Burntisland	2.15 „	$16\frac{1}{2}$ „	7 „
Hopetoun House	2.30 „	17 „	$6\frac{1}{2}$ „

The tides at Leith and Kinghorn rise sometimes as high as 19 feet above low-water mark, the average being $17\frac{1}{2}$ feet.

Currents.

There are in the Forth, as elsewhere in similar rivers and arms of the sea, particular currents. Among the most remarkable are those known by the name of *Leakies* above the Queensferry, which are particularly observed from Culross to Alloa. "These consist in an intermission of the tide at certain places during the flood, and before high water the sea ebbs. On the contrary, while the sea ebbs, and before low water, the ebb intermits, and a flow commencing, continues some time; after which the ebbing is resumed until low water. This is seen during two hours, and the irregularity occupies more or less of the river according as it is spring or neap tide."

Winds.

Certain winds, acting upon the great mass of the Atlantic Ocean, affect the times at which it is high or low water in the Forth, while their effect upon the extent of the rise or fall of its waters is frequently very considerable.

The prevailing winds of the Forth will be seen by the following table, constructed from observations taken every day, at ten o'clock forenoon, on the island of Inchkeith, for the ten successive years ending on 31st December 1826.

Direction of the Winds.	Description of the Winds.				
	Light Airs.	Breezes.	Gales.	Storms.	Total.
South	96	165	29	2	292
South-West	42	181	111	5	339
West	275	807	267	22	1371
North-West	44	157	13	3	217
North	26	105	20	1	152
North-East	68	90	23	24	205
East	334	345	34	26	739
South-East	104	109	6	5	224
Changeable	101	12	...	...	113
	1090	1971	503	88	3652

The prevailing winds and their relative force, as indicated at the Calton Hill Observatory, may also be seen from the following table constructed from the observations taken there every day under the superintendence of the astronomical observer for the same ten years, ending on 31st December 1826. The entry in the register for each day is applicable to the winds of its whole 24 hours.

Direction of the Winds.	Description of the Winds.						
	Moderate and Calm.	Brisk.	Sharp.	High.	Very High.	Extremely High.	Total.
South	85	2	...	17	3	4	111
South-West.....	310	43	1	178	68	30	630
West..............	444	54	3	235	54	8	798
North-West.....	207	33	4	143	48	9	444
North	61	6	4	17	5	...	93
North-East	122	11	2	21	2	...	158
East..............	381	37	4	45	4	...	471
South-East......	131	8	3	14	2	...	158
Changeable.....	588	44	4	119	29	29	789
	2329	238	25	789	215	56	3652

From these tables it will be observed that the prevailing winds in the Forth, the gales and the storms at Inchkeith, and the "very high" and "extremely high" winds at the Calton Hill Observatory, chiefly proceed from westerly directions.

Waters. The waters of the Forth and its tributary streams are all fresh until they mingle with that of the ocean. Long before the river becomes two miles wide they acquire a saltness which differs little, if at all, from that of the sea. The water in the neighbourhood of the coal-works on the Forth has been often evaporated for the sake of the salt, which was here at one time an extensive article of manufacture.

The constituent parts of 10,000 parts of the waters of the Forth were found by Mr Murray, in the course of three different analyses made in different ways, to contain

Muriate of soda	242·51	245·04	220·01
Sulphate of magnesia...............	7·86	17·04	...
Sulphate of soda......................	9·99	2·66	33·16
Muriate of magnesia	34·49	28·63	42·08
Muriate of lime	...	...	7·84
Sulphate of lime......................	9·45	9·72	...
	304·30	303·09	303·09

Mr Murray placed most confidence in the results obtained from the last of these analyses.

Minerals on the banks. The minerals of which the banks of the Forth are composed will be found described under the counties of East Lothian, Mid-Lothian, West Lothian, Stirling, Clackmannan, Perth, and Fife, by all of which the Forth is bounded. Coal, besides being wrought in these counties, was once worked near Culross and Torryburn under the bed of the river, and partly by pits within high-water mark. At the mouths of these pits there were piers, at which vessels were loaded with coals. But the mines above referred to have for many years been filled with water. At West Wemyss, however, there are still extensive coal mines worked under the sea.

Bed of the river. The bed of the Forth consists to a great extent of mud, and in many places the sandstone bottom is covered with it to the depth of 20 feet. Its banks above Alloa, and a great way below that place, are formed of this material, which is brought down by the waters from the higher levels; and the carses of Stirling and Falkirk, &c., which have been formed from its accumulation, are secured at their lowest levels by sea dykes against inundations occasioned by the rise of the tides. The recent alluvial cover to the westward of Alloa has been found by Mr Bald in some places to be no less than 90 feet deep, and to contain trunks and branches of large trees, and beds of sand and sea shells, particularly of the oyster, cockle, mussel, donax, &c.; and similar beds of shells not only abound at and below Alloa, but are found several miles to the westward of Stirling similarly situated. Many of the oyster-shells are of uncommon thickness, and larger than any specimens that can now be found. What makes the westerly position in which these uncommonly large shells are found very remarkable is that there are no specimens of the oyster now found farther up the Forth than Queensferry.

There is also a bed of marine shells on the banks of the Forth near Borrowstownness about three miles in length and several feet in thickness, and which is situated many feet above the present level of the waters of the Forth. This circumstance would favour the opinion that the sea in this quarter had at one time occupied a higher elevation in relation to the land than at present; an opinion which is farther supported by the fact of the skeleton of a large whale having been found some time ago in the lands of Airthrey, near Stirling. The surface of the ground where the remains of this huge marine animal were deposited was ascertained by Mr Stevenson to be 24 feet 9 inches above the present level of the high water of the Forth at spring tides. The skeleton of another whale, with a bone harpoon sticking in it, was also found seven miles farther inland, on what is now the Blair Drummond moss.

But if the land has been gaining on the waters in the upper part of the Forth, ground has been lost farther down the estuary. The sea has made considerable encroachments at North Berwick; at Newhaven an arsenal and dock, built in the reign of James IV. in the fifteenth century, has been swept away. On the coast of Fife, in 1803, the last remains of the Priory of Crail and the ground on which it stood met with a similar fate; and no traces can now be found of the lands which extended into the sea, and formed, in 1225, the estuary, the fisheries of which were then a subject of an important dispute between the monks of Dryburgh and those of the Isle of May; all that now remains of this estuary is a small streamlet called the Drill burn, which flows through a portion of the sands in West Anstruther harbour.

At Largo Bay the sea seems now to be covering ground which was formerly dry land. Here a submarine forest has been discovered, the roots of the trees penetrating into a brown clay, over which is irregularly distributed a covering of sand and fine gravel. The peat upon it is composed of land and fresh-water plants, amongst which are hazel nuts, and the remains of birch, hazel, and alder trees. The root of one tree, apparently an alder, was here traced by Dr Fleming to an extent of more than 6 feet from the trunk.

Sea-weed. On almost all the shores of the Forth there is an abundant supply of sea-weed, which has often been burned at various places to form kelp, but this trade is now given up. The produce of the rocks and what is cast ashore in storms is now therefore only used as manure.

Large fishes. Numerous porpesses are often seen tumbling and disporting in the firth, and seals lying on the rocks or swimming along the coasts. Sharks of several species have occasionally made their appearance, and have been brought ashore by the fishermen in their nets about Anstruther and elsewhere. Numerous cetacea from 20 to 30 feet long have often been stranded in the Forth. From twenty-five to thirty of these animals were at one time on shore between Cambuskenneth and Alloa. A male Beluga or white whale, apparently of full growth, appeared in its waters in 1815. It was killed by the salmon fishers near the same place, and sent to Edinburgh, where it was dissected by the late Dr Barclay.

Salmon. The salmon is abundant in the Forth, and salmon fisheries have been established for many years at Stirling, Abercorn, near Queensferry, and many other places on both sides of the firth, as far down as Largo Bay. The whole of these fisheries belong to thirty proprietors, and such of them as were let in 1854 produced a gross rental of L.1316. The rent of the town of Stirling's fishing then amounted to L.354, of another proprietor to L.240, of another to L.126, of two others to L.70 each, and others were let under that

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sum, a few at a rent of L.5, and thirteen of them brought no rent at all, as they appear to have been considered of little value.

Herrings, &c.

Herrings are also plentiful in the Forth, and at various fishing stations the fishery is prosecuted successfully. To give some idea of its extent, in the Anstruther district in Fife, which includes all the sea-ports from St Andrews to Buckhaven inclusive, the total number of barrels or crans of herrings taken (1854) amounted to 17,906½, whereof 11,468 were sold fresh, 3699½ were sold and exported to Continental markets, and 2739 cured and sent to Ireland.

The number of full-sized cod and ling caught and cured was 84,855, of which 1089 cwts. were dried, and 1865½ barrels were pickled. In addition to these, 9958 cwts. of full-sized cod and ling were caught and sold in a green state and sent to and consumed in Leeds, Preston, Birmingham, Edinburgh, Glasgow, Cupar, Stirling, Perth, Dundee, &c. The value of the annual average of haddocks sold fresh has lately been estimated at L.4000, of smoked L.12,000, of turbot, halibut, lobsters, crabs, &c., L.458, and of periwinkles, L.136.

There were engaged in this district, in 1854, 500 boats, 2099 fishermen, 97 coopers, 1444 gutters and packers, and 1063 labourers, all in the employment of 68 fish-curers. The value of the boats and their appurtenances was reported to the fishery commissioners to be L.61,991.

In the Leith district, which includes all the portion of the firth above North Berwick on the south, and East Wemyss on the north shore, the total number of crans or barrels of herrings taken (in 1854) were 16,045½, whereof 6695½ were cured, and 9350 were sold fresh; 13,714½ were sold to Continental markets, and 496½ sold and sent to Ireland. The number of ling and cod caught by the fishermen of this district were all sold fresh, and have been estimated to the commissioners at 5900. All the other fish caught here were also sold and consumed in a fresh state. There were employed in this trade, in 1854, 354 boats, 1166 fishermen, 100 coopers, 489 gutters and packers, and 224 labourers, all in the employment of 25 curers. The value of the boats and their appurtenances was reported to be L.21,771.

Besides the fisheries in the Forth above stated, there were 35 boats, 134 fishermen, 25 coopers, 205 gutters and packers, and 40 labourers employed in the same trade by 2 curers at Canty Bay, and 30 at Dunbar, and the fish taken by them are generally sold fresh.

In addition to the Scotch fishermen, it may be mentioned that all parts of the firth are occasionally fished by English vessels, and a dozen at a time of English fishing smacks, and as many as 20 French boats, have been occasionally seen by the Anstruther fishermen to be so employed; 40 sail of foreign vessels were at one time known to have been fishing cod near St Abbs' Head.

Shell-fish, &c.

Lobsters and crabs are caught at all the fishing-stations in the Forth, as well as in the Anstruther district. Mussels, cockels, limpets, and whelks are also collected and sold in great quantities at the places where they abound, and oysters are extensively fished at the oyster beds, which are met with near Inchkeith and farther up the Forth.

Wild-fowl.

There is nothing remarkable about the wild fowl resorting to the firth in winter. The solan geese of the Bass have been already described under the head BASS, to which the reader is referred.

Islands.

Besides the Bass, in the entrance to the Forth, there is another island, the May; and the larger islands farther up the Forth are Inchkeith, Inchcolm, and Inchgarvey, which will be found described in separate articles. The smaller islands are Fidra, the Lamb, and Craigleith, near the Bass, and Mickry and Cramond islands, near Inchcolm.

Fords, and peat accumulation.

The principal obstructions to the navigation of the Forth between Alloa and Stirling have hitherto arisen in a great measure from the two fords of the river, the one called the Town ford and the other the Abbey ford, and from the channel being rendered shallow partly by large boulders and partly by accumulations of peat. The peat accumulations have arisen chiefly from the proprietors above Stirling clearing several thousand acres of their lands for cultivation, by removing the peat which covers them, and moving it into the river in order to be carried away by the current to the sea. This practice has been followed since 1732. The moss covering the soil varies in depth from 14 to 4 or 5 feet, but the greater proportion is 10 feet. Mr Drummond of Blair-Drummond, from 1783 to 1839, floated away upwards of 1600 acres of this substance.

Sand-banks.

The principal sandbanks which obstruct the navigation farther down the firth are the Drum-sands, near Cramond, and the Sand-end on the east of Burntisland harbour.

Dangerous rocks.

The principal rocks which require to be avoided by the mariner are the South Carr Reef, lying N.N.W. from Dunbar, the North Carr, about a mile and a quarter east of Fifeness, the Blae to the west of Kinghorn Ness, the Commons to the west of Burntisland, Craig Waugh S.E.½E. of Inchkeith, and the Gunnet Rock, Pallas Rock, Long Craig, Briggs, and Harwit in its neighbourhood; and several miles farther west and nearer Inchcolm, the Oxcares, Carcraig, and Mickry Stone. Many of these rocks are seen at the lowest ebbs; their position, together with the different land-marks, which are necessary to point them out to the mariner, are delineated on the Admiralty Charts, and the sailing directions for the Frith of Forth, contained in the *Coaster's Assistant*, which is published in Leith. To show their position still better, floating buoys have been placed upon Craig Waugh, the Gunnet, the Harwit, and the Pallas Rocks; and beacons have been erected on the Oxcares, the North Carr, and on the Long Craig, and on most of the other dangerous rocks, and on several shoals and sand-banks.

Beacons and buoys

Light-houses.

Besides these provisions for aiding the navigation, there are two lighthouses on the Isle of May, one on the Island of Inchkeith, and various other lighthouses are now erected on all the harbours and landing places of importance in the firth.

Anchorages.

The anchorage of the Frith of Forth is excellent. Mr Osborne, in a report to the Lords of the Admiralty on 2d May 1853, says of it, "Between the Humber and the Frith of Cromarty there is no other harbour or anchorage into which large ships of war can safely run for shelter or rendezvous other than the Frith of Forth, and more particularly in the reach above the Queensferry, where the shelter is complete. But as the Frith of Cromarty is away from all important interests, the Frith of Forth must be considered the only war port north of the Humber, and therefore a most fitting place for a naval arsenal." But besides the great and important anchorage at St Margaret's Hope, in the reach above the Queensferry, which is more particularly referred to in this Admiralty Report, Leith Roads to the west of Inchkeith is another which is capable of holding a large fleet of ships of war of any size. The minor anchorages in the firth, which are also very good, are at Aberlady Bay, the western part of Largo Bay, Burntisland, St Davids, Limekilns, &c.

Harbours.

The landing-places in the Forth are, on the south side the harbours of Dunbar, North Berwick, Port Seton, Morrison's Haven, Fisherrow, Leith, Newhaven, Trinity, Granton, South Queensferry, Borrowstownness, Grangemouth, and Stirling shore, and on the north side Crail, Anstruther, Elie, Pittenweem, Leven, Methel, West Wemyss, Dysart, Kirkcaldy, Kinghorn, Pettycur, Burntisland, Starleyburn, Aberdour, St Davids, Inverkeithing, North Queensferry, Charleston, Crombie Point, Culross, Kincardine, and Alloa. Great improvements and new erections have been lately made at most of these harbours which are of any note; and in particular, the Duke of Buccleuch's magnificent harbour in

Forth. progress of formation at Granton, and the extension of Leith Pier into deep water may be referred to. Of less magnitude is the deepening of the channel of the Forth between Alloa and Stirling by commissioners acting under the Act of Parliament 6th and 7th Victoria, cap. 47. Since the passing of this act in 1843, a channel of about 500 yards in length has been formed through the Abbey ford, giving about 3 feet 6 inches greater depth of water than formerly. A channel about 1000 yards in length has also been formed through the Town ford, which is not yet fully completed as regards its depth of water. In these operations many thousands of large boulder stones and the peat accumulations which formed obstructions to the navigation have been removed, and no doubt is entertained by the inspectors, who have reported to Government on the subject, but a depth of 16 or 17 feet at spring-tides will be obtained up to Stirling when the works in progress are completed. Upwards of L.9000 (including the expense of the act and of erecting a quay at Stirling) have already been expended by the Harbour Commissioners on these operations, and L.7000 more is about to be expended upon them. This sum is to be paid to the commissioners by the town-council of Glasgow for damage likely to arise to the improvements in progress on the Forth, from the liberty obtained by the City of Glasgow to draw a large quantity of water from Loch Katerine. In addition to these sums the revenue of the Forth Commissioners, which is considerable, will enable them still further to extend their works.

Further, the low-water ferry landing-place at Burntisland, belonging to the Edinburgh, Perth, and Dundee Railway Company, is a great improvement at that port; and at Kirkcaldy, Buckhaven, and other harbours, extensive works are in progress under Harbour Commissioners.

Coasting and foreign trade. The coasting and foreign trade of the Forth is carried on in vessels varying in size from 18 to 500 tons. The principal port to which they belong is Leith; but there are several whalers and large vessels engaged in the Australian, American, Mediterranean, and Baltic trades, which belong to other ports in the Forth.

The traffic in goods and passengers between the ports in the Forth and London, Greenock, Glasgow, Liverpool, Hull, Newcastle, Dundee, Perth, Aberdeen, Inverness, Peterhead, and almost every considerable seaport in Scotland, is conducted chiefly by vessels of joint-stock companies, which vessels sail periodically. Joint-stock companies are also engaged in the Leith trade with Hamburgh and Rotterdam. The Glasgow, Greenock, and Liverpool trade is chiefly conducted through the Forth and Clyde Canal, as to which see NAVIGATION, *Inland*, and GRANGEMOUTH.

Forth.

The number and tonnage of the vessels belonging to the ports in the Forth in 1855 are as follow:—

At Alloa, including the creeks of Kincardine and Stirling, 74 vessels, with a tonnage of	12,402
At Borrowstownness, including the creeks of Charleston and Limekilns, 47 vessels, with a tonnage of......	3,781
At Grangemouth, 54 vessels, with a tonnage of.........	9,233
At Inverkeithing, 23 vessels, with a tonnage of.........	2,361
At Kirkcaldy, including the creeks of Largo, Leven, Wemyss, Dysart, Kinghorn, Burntisland, and Aberdour, 60 vessels, with a tonnage of	7,687
At Leith, including the creeks of Granton, Fisherrow, Cockenzie, and Dunbar, 176 vessels, with a tonnage of..	25,404
Total 434 vessels, with a total tonnage of	60,868

Bridges and ferries. To facilitate the communication between the northern and southern parts of Scotland by a passage across the Forth, wooden bridges were erected at an early period, and the old stone bridge of Stirling was erected before 1571; the new stone bridge and the railway bridge near it were erected only a few years ago. There was once a project of erecting a suspension bridge at the Queensferry, and another project of making a tunnel there; but both the schemes were abandoned.

The passage of the river and firth by ferries has been an object of legislative enactment since 1467. Before the introduction of steam navigation, the traffic at these ferries was chiefly conducted by open boats, pinnaces, and yawls of various sizes, and from the want of low water piers they seldom departed from either side except at high water. Most of these ferries are still private property. The private rights of the Queensferry passage were purchased by Parliamentary Trustees in 1809, and large sums have been expended on its improvement. The ferries of Kinghorn and Burntisland were also under Parliamentary Trustees for many years; but they have now ceased to be so, and the Fife and Mid-Lothian ferries and their landing-places at Kinghorn, Pettycur, and Burntisland, are now the property of the Edinburgh, Perth, and Dundee Railway Company, who afford the ferry accommodation as a portion of the railway business. For the extent and particulars of this trade, reference is made to the article FIFE.

FORTIFICATION

Is the art of securing a portion of ground, whether occupied by a town, or including within it a dock-yard, port, or harbour, or serving, in military language, as the position of an army, from the attack of an enemy, by surrounding or covering it with works of defence; and as such works are so many obstacles placed in the way of the advance of their assailants, whilst they are at the same time the means of sheltering the defenders, it is the art of enabling a small number of men to defend themselves against the attack of a much larger. Various modifying terms have been adopted in connection with the general one of fortification, but none of them are of much use in considering this subject, and some may lead to error, by inducing an engineer to restrict himself under some circumstances to a very limited view of his subject. Thus, fortification natural and fortification artificial, imply a very useless distinction, as every engineer must avail himself both of the natural advantages or obstacles of the ground, as well as of the obstacles his science and genius enable him to add to them; and thus in every fortification nature and art must act together. Again, fortification regular and fortification irregular, are terms equally defective, as no fortification can be possibly regular unless it should so happen that the ground it occupies, as well as the ground surrounding it, is on all sides perfectly identical in its levels and general character. Fortification permanent and fortification field or temporary, refer again only to the immediate object of the works, or to the application of the science, and in no way affect its principles, which remain the same whether the work is a simple earthen intrenchment, or a great fortress surrounded by masonry walls. Fortification offensive and fortification defensive, are of all the most objectionable terms, since, strange as it may appear, they imply a contradiction to fact, as the perfection of defence depends as much on its active or offensive operations as on the protection its covering works afford, whilst the perfection of attack is equally dependent on the skill with which its covering works are constructed and pushed forward towards the fortress attacked, as on its offensive operations, or on the fire of its batteries.

The principles of defence then should be studied unshackled by any of these limiting distinctions, and the engineer should apply his means to his end, using without restriction the works best suited to his purpose; and it is in this way that the study of the subject will be here treated.

ELEMENTARY FORTIFICATION.

It is often desirable to examine the exact meaning of technical words, as a ready mode of acquiring a distinct notion of the ideas they were intended to convey; and of obtaining a glimpse of the historical progress of the science in which they are used. Fortify, Fortification, Fortress, Fort, are all words depending on the Latin words *fortis*, *forte*, strong, and *fortifico* or *forte facio*, to make strong; hence the idea they suggest is that, by some artificial or other arrangement, additional strength is bestowed upon one combatant over another, or upon one party of combatants over another party. A shield, the trunk of a tree, or bank of earth, or any other similar contrivance which shelters the body of one soldier from the missiles of his opponent whilst it leaves him free to discharge his own, may be considered a simple element of fortification.

A bank of earth, when reduced to the requisite thickness, and moulded into a proper form, with such slopes as the particular tenacity of the earth may require to insure stability, or which the intended direction of the fire over its summit may render necessary, becomes a parapet, so called from the Italian words *para*, a defence or guard, and *petto*, the breast, or, in English, a breastwork. If the breastwork or parapet were only made sufficiently high to permit the soldier to fire over it, he would be greatly exposed after firing, and be forced to crouch down in order to obtain cover. The parapet is therefore made sufficiently high to cover the soldier when standing up, so as to enable him with ease and security to reload, as well as to move from one place to another. This increased height has rendered it necessary to introduce a banquette or step (accessible by an easy slope) from which the soldier can fire and then retire by the interior slope to the lower ground behind it; the name banquette being derived from banchetta, a little bench or step. As parapets are usually formed artificially, the earth for their construction is derived from a ditch, which being dug immediately in front of and parallel to the parapet, forms by its depth an additional obstruction to an advancing enemy. Ordinary intrenchments are formed of the simple parapet and ditch, but in forts and fortresses the height is still further augmented by elevating the parapet on another mound of earth called the rampart (*riparo*, in Italian), and as this additional mass requires a greater quantity of earth, the ditch is also made both wider and deeper. In this manner the difficulties of attack are increased, additional cover is given to the magazines or other buildings within the fortress, and the command over the country is increased and improved in efficiency, by elevating the soldier so that he can see over the many minor obstacles likely to restrict his field of view. A natural and simple mode of distinction may be therefore derived from the presence or absence of a rampart, and the two leading sections of the subject stated thus: parapet, or field fortification, and rampart, or town fortification.

In order to study efficiently the results of combining together these simple elements, and forming from them extensive works of defence, it is necessary that we should know the manner in which such works are represented on paper. As in architecture, of which in earlier times fortification was only a military branch, this is effected by the plan, the section, and the elevation, of which the two first are the most important. The plan of a work is the orthographic projection of the lines of intersection of the planes of its slopes on the plane of construction. The elevation is a similar projection on a vertical plane. The section or

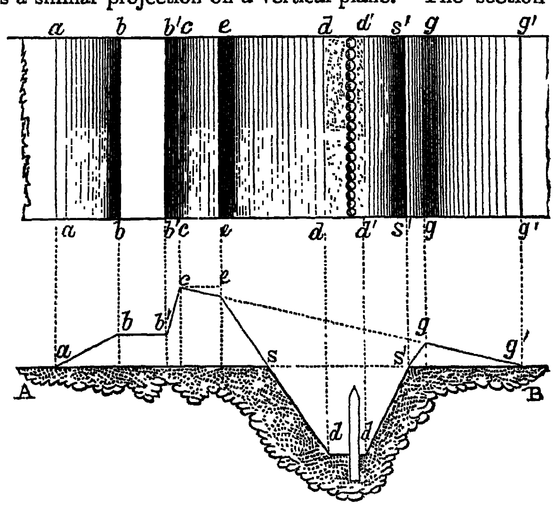

Fig. 1.

profile is taken on a plane perpendicular to the lines of intersection of the planes or slopes, and therefore represents

the traces of these planes on the sectional plane. Fig. 1 represents a small portion of a simple parapet in plan and profile, and leads to the following explanation of terms:—

In the plan, *cc* represents the crest of the parapet or highest ridge line of the work. In delineating the mere outline form of a work, it is this line which is always drawn, and is called the trace. Between *cc* and *ee* is the superior slope; between *ee* and a line parallel to it, through *s* of the profile, is the exterior slope, prolonged in this case to the bottom of the ditch *dd*, being continuous with the scarp *sd*; *gg*, crest of the glacis, or ridge of a slightly elevated mound of earth raised on the exterior edge of the ditch, or of the counterscarp, and sloping gently outward, so as to bring the assailants directly in the prolongation of the superior slope of the parapet, and therefore into the line of fire from its crest, and by its elevation to increase the amount of descent into the ditch. Within the crest of the parapet is seen the interior slope of the parapet, bounded by *b′b′*, the banquette, between *b′b′* and *bb*, and the interior slope of the banquette, bounded by *aa*.

Relief.—This term is adopted to show either the height of any point of the work above the plane of construction, which is sometimes equivalent to the plane of sight, and may then be called constructive relief; or the height above the bottom of the ditch, when it may be called absolute relief. The relief taken in the latter sense is a very important datum, as it expresses the total amount of the obstruction offered by the parapet and ditch to the ascent of the assailant, and also as it is necessary in regulating the length of lines, which mutually defend each other, as will be seen hereafter. Relief of a work refers to the relief of the crest of its parapet. Command of a work means the height of the crest of its parapet, either above the plane of sight if horizontal, or above any point of that plane specially referred to, or above the crest of the parapet of any other work in front of it; the difference of height, therefore, between the crest of the parapet in fig. 1 over the crest of the glacis is the command of the parapet over the glacis; in the one case it is absolute, in the other relative command. An examination of the profile figure brings also under consideration, in respect to the row of palisades, another simple principle, namely, that an enemy should be stopped as he advances to the parapet by every obstacle which can be thrown in his way, and thus kept exposed as long as possible to the fire either of the

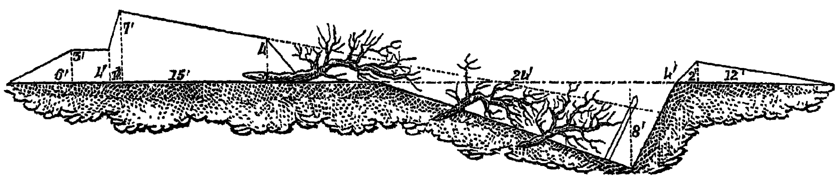

Fig. 2.

work in front of him, or of some other work taking him in flank; if simply opposed by a front fire from the parapet, palisades, arranged as these are, would only check for a very short time the progress of an enemy, and are more useful for gaining time on the part of the defenders than for ultimate defence.

Obstacles against approaches.

Many other obstacles may, however, be so arranged as to assist materially in rendering even the simple direct fire more effective.

Abattis.—These are formed of trees cut down, and arranged side by side with the branches interlaced together outwards, and the stems inwards; the branches should be freed from foliage, and their ends cut sharp. They may

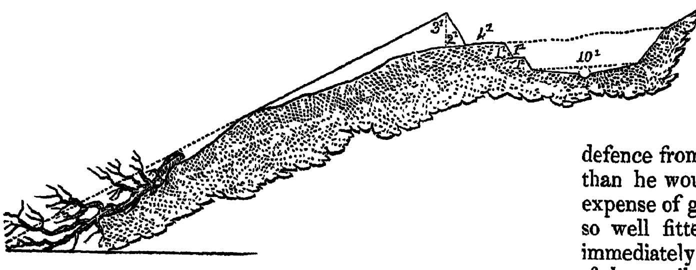

Fig. 3.

be arranged either in one or more rows, and when placed so that the fire from the parapet should sweep along their summits, they would, their stems being firmly fastened down by pickets to the ground and partly buried in it, occasion great loss to the enemy whilst attempting to remove them under fire.

Fig. 2 exhibits an arrangement of this kind; and it will be observed that on this profile the exterior slope of the parapet and the scarp have been formed into one gentle slope, whilst the counterscarp retains its ordinary slope. By this modification the difficulty of descending into the ditch remains as before, and the sloping pickets in front of the abattis prevents the assailants from immediately endeavouring to clear it away. In simple inclosed works, such as redoubts, as well as in lines, the defence frequently depends on direct fire alone; and in these cases an arrangement of the profile, as here figured with obstacles, would be far more effective in checking an enemy than an ordinary profile though in itself more difficult of ascent, without such obstacles, and in consequence would render it impossible that an ordinarily watchful garrison should be surprised; and this is a very important consideration, as a vigorous and bold enemy could scarcely be stopped if he had succeeded in arriving at the foot of the scarp unchecked.

Fig. 3 is another adaptation of an abattis formed only of large branches securely picketed down to the ground. In this case the form of the ground is taken advantage of, and even the profile of the defensive line is modified, a trench being cut out behind it, and the banquette being formed on the surface of the ground itself. The engineer will often, by simple arrangements of this kind, be able to carry his defensive lines over a large extent of ground in a short period of time, and to obtain a much more effective defence from the natural facilities afforded by the ground than he would have done by superadding to them, at the expense of great labour and much time, elevated works, not so well fitted to scour the face of the ground, and to act immediately upon the obstacles then checking the progress of the assailants.

Chevaux-de-frise.—The cheval-de-frise is an artificial substitute for an abattis. It consists of a strong horizontal beam, about 12 feet long and 9 inches square, through which

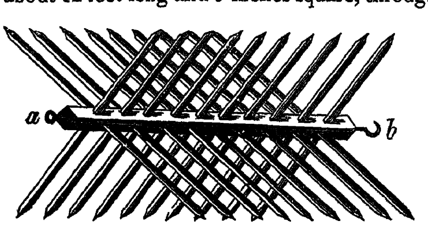

Fig. 4.

are passed strong lance-like rods of either wood or iron, sharp at both ends, and about 6 inches apart. Several of these

may be joined together by means of a ring at one end and the hook at the other end of the beam. The difficulty of making chevaux-de-frise, as their construction requires a number of carpenters and much wood, renders them unfitted for sudden emergencies, and they are also, under ordinary circumstances, easily removed or destroyed; but with these, as with all military implements, there may be opportunities of using them with effect. If planted at the bottom of a hollow, exposed to a well-directed fire, and so placed that they must either be pushed uphill forward or pulled uphill backward, and then secured to the ground, either by chains, or by being fastened to upright posts, they would often prove a formidable obstacle. They are more generally used as a barrier to close an open work.

Fraises.—The fraise is distinguished from the palisade by being fixed in a horizontal, or nearly a horizontal position.

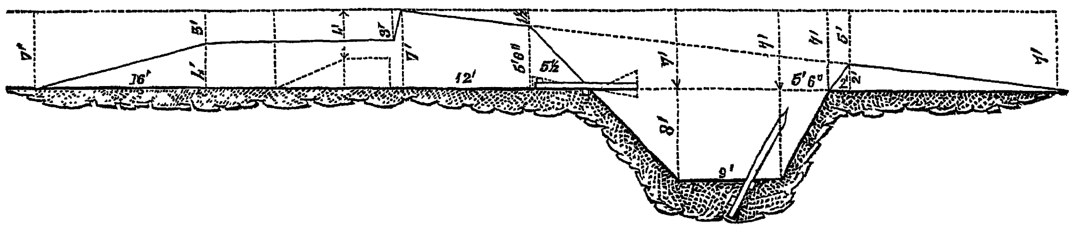

Fig. 5.

They are made about 10 feet long and 5 inches thick, being bound together by two ties, one nailed above and the other below them; without which precaution they would be much more easily torn away. They are sometimes fixed on the counterscarp as well as on the scarp.

Fig. 5 represents, in section, a row of fraises on the scarp. In this profile the ordinary banquette for musketry is represented by dotted lines below a wider terreplein formed for artillery to fire over the parapet, or a barbette, as it is usually called; but this will be more fully explained in a future paragraph.

Chausse-trapes.—These are made of four points of iron so arranged that one should always project upward in whatever manner they may be thrown on the ground. The points are either 2 or 4 inches long, and they are *sown* over a space about 12 feet broad. Without doubt, troops coming suddenly, and in the dark, on such obstacles as these, would be much annoyed by them; and, in consequence, they were formerly much used, more so than they are now.

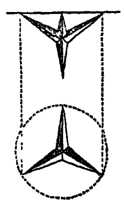

Fig. 6.

Trous-de-loup, or wolf-traps, are holes made in the ground in the form of a truncated cone, the sides of which are as little sloped as is consistent with the stability of the soil. They are made from 5 to 6 feet deep, and 6 or 8 feet in diameter. At the bottom a sharp picket is fixed, from 3 to 4 feet long, or, in place of it, the branch of a tree cut into sharp points, or a number of smaller sharp pickets, or a quantity of chausee-trapes. The figure shows the arrangement of trous-de-loup proposed by Wênzêl, in plan and in section. If along the defensive line of a position, either on the glacis or on the scarp, when gradually sloped as in fig. 2, small trees or shrubs are planted, and on an emergency cut down, and the points of their stumps sharpened, they become very annoying to an assailant. Harrows have also been used, and, in short, every expedient which ingenuity can suggest should be adopted by an engineer to check the progress of an advancing enemy, and to keep him as long as possible under fire.

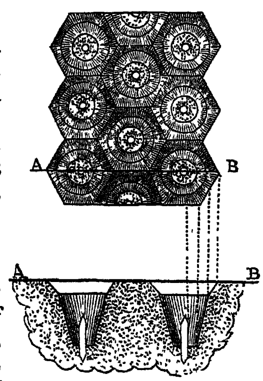

Fig. 7.

Stockades.—Before proceeding to an investigation of the principles which should regulate the relief and thickness of ordinary parapets, viewed in reference to simple defensive lines and to direct fire, it is right to notice the stockade as a substitute, and in some circumstances an advantageous one, for a parapet. The stockade is formed of either one row of stout palisades, or two rows, one behind the other; and the following is one of the simplest modes of constructing it:—

A row of very strong palisades, pointed at the top, from 8 to 12 inches square, is formed, with intervals of 3 inches between every two palisades, and behind this row is formed another corresponding to the open intervals in the first. These second palisades are only from 5 to 7 inches thick, and are cut square at the top, every second one being cut short, or to the length of $4\frac{1}{2}$ inches, so as to fire over it as through a loophole. This stockade is shown in plan, elevation, and section; it has a banquette of earth, which may be replaced when desirable by a wooden step. By cutting out the triangular portion shown in the section, and throwing the earth up against the front of the palisades, an exterior slope and scarp are formed which keeps an enemy constantly in view. Such a stockade as this brought up close to the edge of a steep bank, requiring defence, has a great advantage over a parapet, as the men behind it have a much more effective command of the ground before them when firing through the loopholes than they could possibly have when firing over a parapet. It is here supposed that artillery fire cannot be brought to act in front against the stockade, but it may possibly be brought to act against it in a longitudinal, or, as it is called, enfilade direction; and in this case the line of stockades should be interrupted by traverses, which are usually banks of earth placed transversely to the line they are intended to protect from enfilade fire.

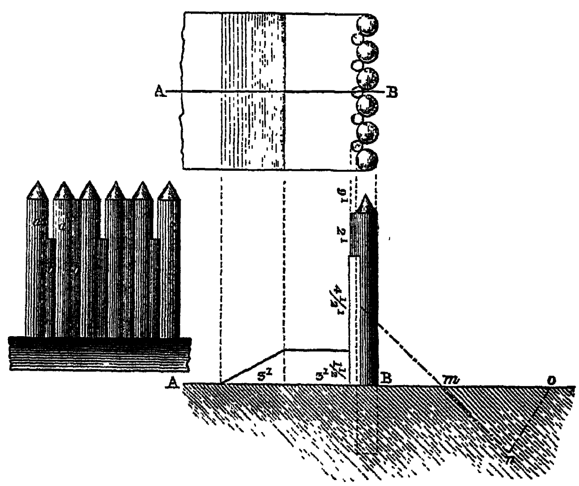

Fig. 8.

Fig. 9 shows the adaptation of a stockade of this description to the defence of precipitous ground. When stockades

are formed into inclosed works, they constitute what are called "tambours."

It may in a similar manner be desirable to throw an ordinary parapet forward to the edge of a bank, the slope of which supplies the function of a scarp, and hence to dig the ditch behind instead of before it, as in fig. 10, where it will be also observed that the slope of the banquette is broken into two steps, the tenacity of the earth when first excavated allowing it to stand firm; and the principle of this excavated form of structure is also adopted in sunken batteries.

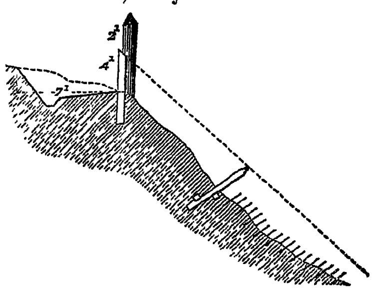

Fig. 9.

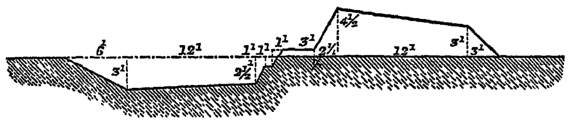

Fig. 10.

Sometimes the object of the parapet is merely cover and not active defence, in which case the banquette is omitted as in

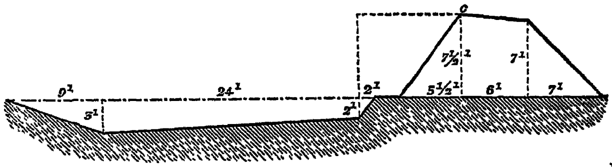

Fig. 11.

fig. 11; and the work is called an epaulement. In this profile it will be observed that a space is left between the face of the epaulement and the internal ditch, which is called a berm. Such a space should always be left, whether the ditch is within or without, when the work is to be formed of any considerable elevation, as it forms a stage upon which the builders can stand, and lessens the height to which the diggers have to throw the earth from the ditch; and it is very important to keep the berm clear by throwing forward or back the earth as quickly as it is raised. The distinguish-

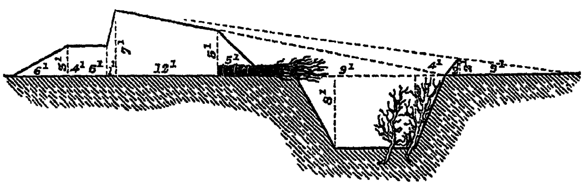

Fig. 12.

ing characteristic of an able engineer is to be found in the power of varying his appliances at will;—thus the abattis may become the fraise, or may displace the palisade, as in fig. 12. Were this principle not kept in view, more evil than good would sometimes result from systematic instruction; as the person who had acquired a knowledge of some one

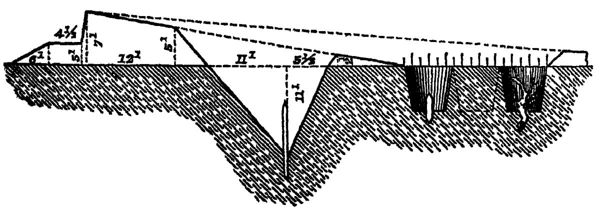

Fig. 13.

contrivance might be found crippled by his constant efforts rather to conform to it than to look about him for some other better fitted for the existing circumstances. In this profile a berm is represented, as it would be difficult to arrange the abattis, and to build the parapets without it.

The arrangement of the trous-de-loup, combined with stakes driven into the ground, is shown in fig. 13, an advanced glacis having been formed of the earth thrown out of the excavations. The ditch is in this case triangular; and it is scarcely necessary to add that the choice of any particular form must be determined by the engineer from a knowledge of the nature of the ground itself, only remembering that the contents of the ditch, or ditches, must supply material for forming the parapet; and further, that as its depth adds to the difficulty of assault, it should not be diminished except from necessity. After these elementary remarks, the student may be considered prepared to enter on the consideration generally of parapet or field fortification.

RULES FOR DETERMINING THE DIMENSIONS OF PARAPETS.

Determination of the Relief of a Parapet.—First, in respect to the protection of troops in a normal position, where the ground is considered horizontal. Now, the minimum for a simple parapet may be here stated at 6′ 6″ as a musket ball would penetrate the parapet for about 6″ below its crest, and the maximum at 8 feet, a height which gives the defenders perfect security under almost every circumstance of fire, including even that of mounted soldiers.

Defilade.—Secondly, where the ground is uneven, and it is necessary to defilade the work from the point or points which command it. Now, figure 14, No. 1, explains the first case in which the points A, B, C, are on the same level, the distance AB being the space intended to be protected by the parapet at C. The line CF represents the supposed height at which it is presumed the assailants may fire, or in this case 8 ft.; BE will be the same; and AD cut by the line drawn from F to E will also be 8 ft. In fig. 14, No. 2, A, B are still considered to be in one horizontal plane, but C is considerably elevated; and hence, adopting the same data as to height, and drawing the line FE and the line CB parallel to it, AD, or the height of the parapet, equal to AI + ID; ID being equal to BE, or CF, or N, the normal height. Calling also AB, or the distance to be covered, d; AH, or the distance from the commanding point, D; HC, or the height of C above A and B, H; we have AI : CH :: AB : BH; or AI : H :: $d : d + \mathrm{D}$; and hence

$$\mathrm{AI} = \frac{d}{d+\mathrm{D}} \cdot \mathrm{H}, \text{ and } \mathrm{AD} = \mathrm{N} + \frac{d}{d+\mathrm{D}} \cdot \mathrm{H} \qquad (1).$$

So that the necessary height of the parapet increases as the height of the commanding point increases, or as the distance AB to be defiladed increases; and diminishes as the distance from the commanding point increases. Taking $\mathrm{D} = 600$ ft., $d = 30$ ft., $\mathrm{H} = 60$ ft., $\mathrm{AI} = \frac{60}{21}$, or 2 ft. 10 in., and AD, or the height of the crest of the parapet, equal to 8 ft. + 2 ft. 10 in. = 10 ft. 10 in.; or taking D = 1200 ft., or 400 yards, AD = 9′ 6″.

Fig. 14, No. 3, represents A lower than B by a quantity = AO = GH = h; hence AD = AO + OI + ID, and

$$\mathrm{OI} = \frac{\mathrm{OB{\cdot}CG}}{\mathrm{BG}} = \frac{d}{\mathrm{D}+d}(\mathrm{H}-h), \text{ or } \mathrm{AD} = \mathrm{N} + h + \frac{d}{\mathrm{D}+d} \cdot (\mathrm{H}-h) \quad \ldots\ldots\ldots\ldots \quad (2);$$

an equation which shows that the deeper A is sunk below B and C, the more elevated must be the parapet, and hence that this is a very unfavourable condition of parapet. For example, let A be 2 ft. below B, and all other data the same, $\frac{d}{\mathrm{D}+d} \cdot (\mathrm{H}-h) = 2$ ft. 9 in., and AD = 8 ft. + 2 ft. 9 in. + 2 ft. = 12 ft. 9 in.; or when D = 1200 ft.,

11 ft. 4 in.; and if it should be necessary to defilade a distance of 90 ft. instead of 30, the heights of the parapet would necessarily become 18 ft. 8 in., and 14 ft. 2 in.

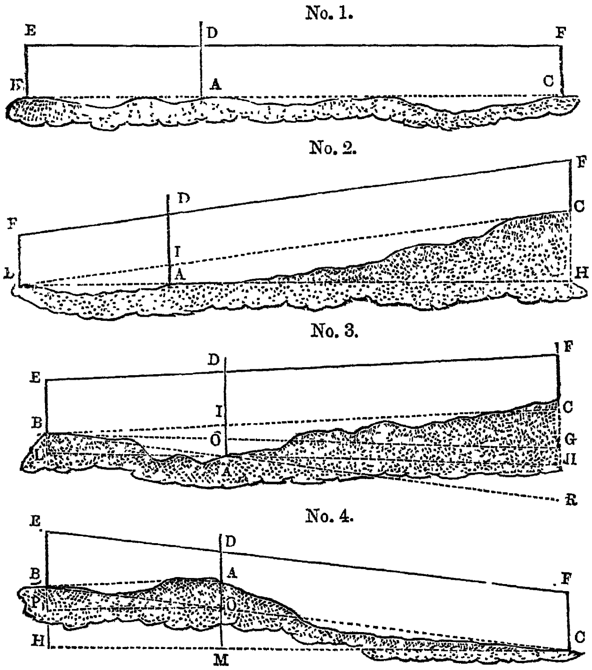

Fig. 14.

Again (fig. 14, No. 4) in this figure A is higher than B, or than C, which is the lowest of all; and if H still represents the difference of level of A and C, and h the difference of level of A and B, $AD = N - h - \frac{d}{D+d}\cdot(H-h)$ . . . (3); and, of course, so far as concerns the height alone of the parapet, this is the most favourable condition of all.

Any other case is easily resolvable by one or other of the formulæ;—thus, when A and C are on the same level, and B higher than A, H becomes O, and No. 2 becomes $AD = N + h - \frac{d}{D+d}\cdot h$.

And in No. 3, if B be higher than A, it becomes positive, and $AD = N + h - \frac{d}{D+d}\cdot(H+h)$ . . . (4); or if h be 0, A and B being on the same level, $AD = N - \frac{d}{D+d}\cdot H$.

In equation (4), if the station C, though below A and B, falls between the horizontal line drawn through A, and the line BR or BA be prolonged till it cuts the surface of the ground, sloping from B towards D, then $\frac{d}{D+d}\cdot(H+h)$ is less than h, and AD is greater than N; but should C be below the line BR, then $\frac{d}{D+d}\cdot(H+h)$ is greater than h, and AD is less than N; or, in other words, if the line of defilade passing through BA meets the ground at R within the prescribed limits of defilade, or the effective ranges of musketry and artillery, which may be now assumed as 500 yards for the first and 1000 yards for the second, if the point C be above that line the parapet at A must be made higher than the normal height, and if below it may be made lower. A comparison between the numerical results attached to equation (2) will exhibit the great disadvantage, to the defenders of simple lines, of having any ground near to their own moderately elevated, and care should be therefore taken either to occupy the ground or to throw back the lines opposite such eminences as far as possible, and should it have the character of a ridge, to bring some portion of the fire of the line to act in the direction of its length. The space AB to be defiladed must depend upon circumstances, but the minimum to allow for a safe communication for the troops behind and actually defending the parapet ought not to be taken below 30 feet, and where troops are required to be drawn up behind the parapet at 90; but in cases of double lines or of inclosed works the distance must of course vary, as the object will then be to protect not only the troops nearest to the enemy from a direct fire, but the troops arming the more distant parapet from a reverse fire. In assuming the normal height as 8 feet, on the supposition that the fire might proceed from mounted soldiers, a condition is adopted which is not generally likely to occur in the attack of intrenchments: if, however, the normal height were assumed at 7 feet, the space behind the parapet must be very imperfectly defiladed, as the trajectory of the ball, being in its descending curve, will come to the ground at a much nearer point than in the original supposition of a straight line of trajectory; and hence it is desirable to adhere to the normal height of 8 feet. In equation (3), and in one case of (4), as explained, the height of the parapet becomes less than N, but should the diminution extend so far as to reduce the height of the parapet below 7 feet, the absolute relief should be restored to its proper amount, or to 7 feet, by excavating the ground behind the parapet, or, in other words, forming a terreplein below the level of the plane of site. In a similar manner, in respect to equation (2), and in one case of (4), where the parapet becomes greater than N, it would be very inconvenient to augment the height above 12 feet, and it is preferable therefore to excavate behind the parapet, whenever the defilade requires so great an increase of height.

Flanking or reciprocal defence.

In the preceding observations the parapet has been considered as forming a simple continuous line, deriving its defence solely from its own direct fire; but such a condition would most frequently be found inapplicable, even as regards form, in consequence of the natural inequalities of the ground, and, with few exceptions, unsatisfactory, as regards defence, in consequence of the imperfect operation of direct fire from the top of a parapet, which can only be brought to bear upon some external line, and must therefore leave the foot of its scarp unseen and unprotected, after an advancing enemy has come within the limiting line of defence. A fire, therefore, so directed as to take the enemy *in flank* has been adopted, and a line or work is therefore said to be flanked when some portion either of its own parapet, or of the parapet of another work, has been so arranged that the fire from it shall take an enemy advancing towards the other portion in flank. In lines of intrenchments this arrangement leads to a bent line, having angles projecting *towards* the country called *salient angles*, and angles retired *from* the country called *re-entering angles*; and it is evident that in this arrangement (fig. 15) the lines AB and AC, which are flanked by BD, CD, do in their turn flank BD and CD, and that flanking defence may therefore be called *reciprocal defence*, a term which more accurately defines its object and value.

Referring back, then, to the subject of defilade, it is evident that a bent line of this kind affords more facility for defilading than a straight one, as it is often possible so to arrange the position of the angles that the salients shall occupy high points of ground, while the re-entering angles though placed on lower shall be compensated for this defect by being further removed from the commanding ground of the enemy.

Enfilade fire.

Whilst a simple straight line has the disadvantage of depending for its defence solely on direct fire, it has the advantage of not being exposed to a fire from the enemy so directed as to sweep along its whole length from one end to

the other, a fire which is called *enfilade* fire, and is necessarily very destructive, as it produces the same effect in

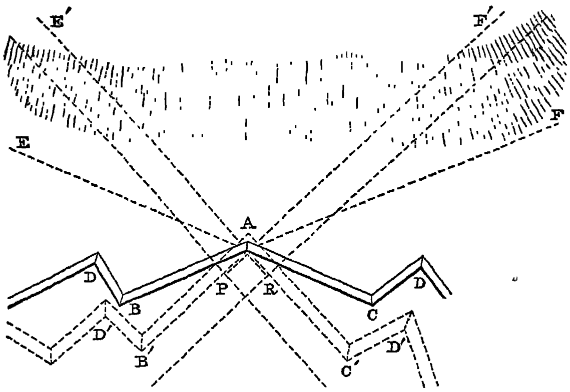

Fig. 15.

attack as a flanking fire in defence, by taking the defenders of the line in flank. To guard against this evil, should it be indispensable to take up a position in front of ground of a superior command, the long lines AB, AC should at least be so directed that their prolongations should fall in low ground at EF, and not as they would do in the case of AB′, AC′, on the high ground at E′F′; and of course, if possible, and where the high ground is not continuous, that the prolongations of both short and long lines should fall on the low ground between the commanding eminences, an arrangement which will be more especially beneficial should the low ground be marshy or otherwise difficult of occupation by an enemy. Such observations as these can only be suggestive, since no fixed rules can be laid down for an engineer in such cases, as he should look at his ground and adjust his works so as to make the most of the natural advantages it presents, and to neutralize, as far as possible, the ill effects of any disadvantages it may possess. To determine the height of the parapet by defilading in the manner stated, it is necessary to have a correct plan of the ground, and to know the exact levels of the points A, B, C, in every case; but the defilading may be effected by levelling poles or boning rods where there is no such plan. In this case the inner boundary of the ground within the parapet required to be defiladed being staked out, a boning rod of 7 or 8 feet high, according to the intended normal height of the parapet, should be placed at BC, on the staked-out line, and another of equal height on the commanding point or ground, fig. 16, supposed to be either at or within the range of the projectiles against the fire of which the work is to be secured. A rod about 12 feet high is then fixed at A, and a cross-piece or marker, as in levelling staves, is raised up or down until it meets the point where the visual line from the top of B to the top of A intersects the pole at A; so that this operation is simply the mechanical determination of the height obtained in the other method by calculation. If it be required to defilade the whole space between two parallel lines, or that included between the two lines forming the salient angle in fig. 15, it is evident that the work must be defiladed from both sides, and further, that the soldiers standing on the banquette of one line should be secured from the fire of the ground in front of the other, or from the fire called "*reverse fire*," as taking them in rear. This is effected by placing a mound of earth or traverse between them, and determining its height as well as the height of the parapets in the following manner:—On the commanding point C is placed the boning rod CD of the normal height, and

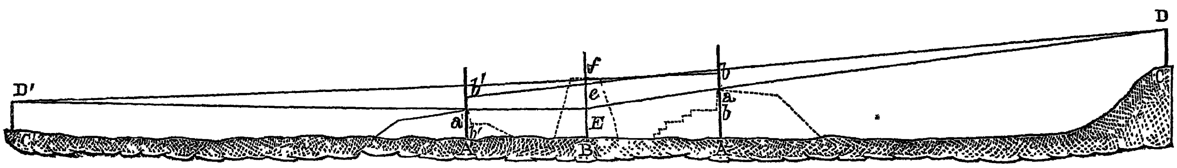

Fig. 16.

another BE, at B, or at the position of the traverse of the same height; then the height of the crest of the parapet of A is determined by the intersection of the visual line from D to E with the pole fixed at A, at the point *a*, which is here high, as C is so much higher than A. See preceding rules and equations. In like manner a pole of the proper height being fixed at the extent of range on the opposite side at C′, the visual line from D′ to E determines the height of the parapet of A′ at *a*′, which is much lower than the parapet of A, as A′ and *b*′ are nearly on the same level. Now, to defilade the banquettes, and to determine the height of the traverse necessary for that purpose, set up on the banquette of A a pole *bb* of the same height as CD, C′D′, BE, and the visual line from D′ to *b* determines the height of the traverse at *f*, which is necessary to secure the banquette of A from the reverse fire of C′, whilst the visual line drawn from D to *b*′ determines the height of the traverse sufficient to protect the banquette of A′ from the reverse fire of C. The application of these principles is shown in reference to a work formed of two lines (or *faces* as they are called), terminating in a *salient* angle, by fig. 17; whether that work is connected with a line of intrenchment as in a *redan*, or is detached as in a *ravelin* and other outworks, or forms part of a peculiar system or arrangement of works as in the *tenaille* system of Montalembert, called by its author the angular system; terms and works which will be hereafter more fully explained. Here the commanding point is supposed to be at M, and to secure the defenders of the face AB from a reverse fire, it is necessary to interpose the traverse *cd*, called from its object a *parados*. The length of the traverse *cd* is determined by the line MB, beyond which it should project

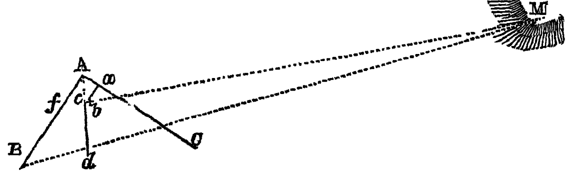

Fig. 17.

sufficiently to give ample security to a space about 50 feet wide behind the parapet. At the other end, the traverse is not carried up to the salient angle, as it would interfere with the communication, but is completed by *ba*, perpendicular to the other face, by which arrangement the space within the salient and the banquette are left free. The two lines M*d*B, and M*cf*, will be directed to points raised above the banquette by the normal height assumed, whether 7 or 8 feet, and thus determine the height of the traverse. It may, however, happen that the commands are so situated as to produce an enfilade fire along both the faces AB, AB′; fig. 18. In this case a small work is formed DAD′ in connection with the parapet, by drawing lines parallel to the crest of CB and C′B′ at a distance from it equal to the breadth of the banquette, and then determining, in the manner explained, the height of A necessary to defilade a certain length of the banquette of CB and C′B′ sweeping

Bonnet.

it, and assuming the greatest of the two as the height of the parapet at A. This work is called a *bonnet;* and when the height necessary to defilade the whole of one or both faces is found to exceed 12 feet, the height of A should be restrained to that limit, and traverses, T, T', T^2 be placed at such distances as shall cause a complete defilade without exceeding the height of 12 feet.

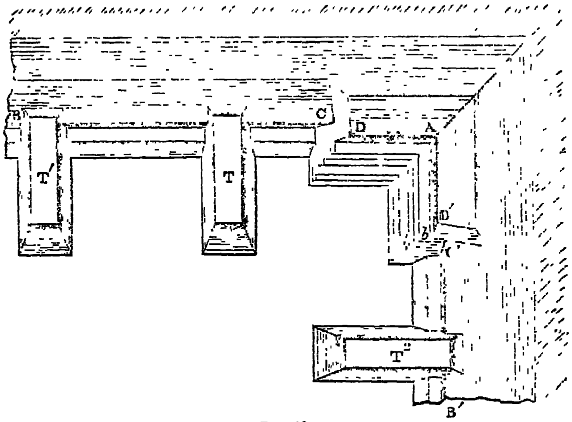

Fig. 18.

The internal space may frequently be sufficiently defiladed by raising the salient portion of the parapet without disturbing the line of direction of the crest; but in that case the banquette of the two faces would not be covered from the enfilade fire, and hence the necessity of a bonnet. The increased height of the parapet of the bonnet renders

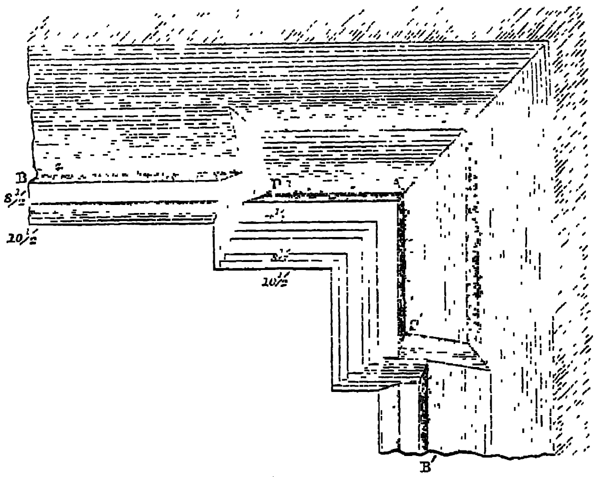

Fig. 19.

it necessary to adopt two banquettes *b*, *b'*, one below the other, and each provided with steps to facilitate ascent, fig. 19. The operation of defilading may be also effected by *planes* of defilade; as, for example, if the line which marks out or limits the space to be defiladed be first drawn, and a plane be supposed to pass through a line either 6 ft. 6 in. or 8 ft. (or whatever height between these may be assumed as the normal height N) above the limiting line, and through a point the same height above the commanding point, this plane will determine the height of the parapet, the crest of which will necessarily be in it. Practically it may be done thus: On the boning rods marking the ends of such portion of the limiting line as can be included in one operation, mark the normal height N considered necessary, and then remembering that a vertical plane through the boning rods would necessarily intersect the defilading plane in a straight line, place one edge of an equilateral-triangular frame of wood in the intersecting line by directing it to the marks on the boning rods, and then attach the frame in that position to an intervening rod. The base of the triangle will now be in the defilading plane, and by moving the triangle on the base as a hinge until the mark on the boning rod at the point of command is just seen along the surface of the frame, it is evident that the triangle itself will then be in that plane also. Fixing the frame in this position, it is only necessary to look along its surface in any direction in order to mark on the boning rods set up on the line of the crest of the parapet the necessary height at each point.

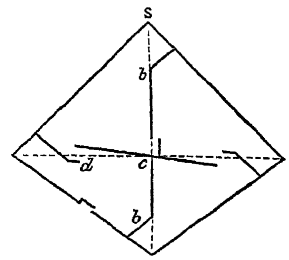

Fig. 20.

Where the parapet is continued not only on the flanks but also in the rear, so as to form an inclosed work, it may often be necessary to defilade it in various directions as in fig. 20. Where two traverses or parados cross each other, they must, of course, be so placed that they shall not only complete the defilade of the whole interior space of the work, but secure from reverse fire the banquette on each side, the normal N being therefore, at least, 6 ft. 6 in. above the banquette. Where traverses of this kind become necessary, the engineer must take into account the space they will occupy, and plan his work accordingly; and should he be able to render the difficulty of attacking one side of his works very great, he may so construct one or more of the traverses that they may be used as retrenchments, and thus increase the means of defence; for example, S being the salient of greatest strength, *bcb* might be first defended, and then *bcd*.

This subject has been enlarged upon because it is one of the most important in engineering, as the safety of a long line of works may be endangered by defective defilading. Though exhibited here in a practical form, it depends essentially on geometrical principles, and instruction therefore in descriptive geometry is now considered essential in all schools of military engineering.

Dimension of profile.

Having determined the relief of the crest of the parapet in reference to the plane of site, all the other vertical dimensions depend upon it, as shewn in several of the preceding figures; whilst the horizontal are regulated either with regard to the slopes required to ensure stability, or the thickness necessary to resist the enemy's missiles. For example, it has been determined that the penetration at a mean range in common earth, after having been dug up and well-rammed, and the thickness for security, are as stated below:—

Weapon.	Penetration.	Required thickness for security.
Musket.	1 ft 6 in.	3 ft.
6-pounder.	3 6 to 4 ft. 6 in.	6
9 „	6 6 to 7 6	9
12 „	8 6 to 10 0	14
18 and 24 pounder	11 6 to 13 0	18

But as neither the 18-pounder nor 24-pounder is now often brought into the field, the thickness of parapet has been usually assumed to be 14 ft. In the Austrian service, in which, as in the Russian, the 18-pounder is a recognised field-gun, it is usual to allow the following thicknesses:—

		Feet.
For defence against	Musket balls	4·3
„	3-pound shot	4·6
„	4 and 6 pound	8·6
„	8 and 12, and 7 and 10 pound howitzers	13·0
„	18-pounder shot	16·6

With light, sandy, or gravelly soil, or, when tamping can only be imperfectly performed, a greater thickness ought to be allowed; and, as the presence of a wide and deep ditch must always materially strengthen the work before which it is placed, there can be no other reason than want of time, want of men, or difficulty of ground,

for reducing the thickness of the parapet below 14, or at the utmost 12 feet. If wood be used, the same authority gives us the necessary thickness for resisting musket balls at from $5\frac{1}{4}$ to $6\frac{1}{4}$ inch; against 3, 4, or 6 lb. shot, 3′ 3″ to 4′ 11″; against 8 and 12 lb. shot, or 7 and 10 lb. shells, 4′ 9″ to 5′ 4″; and against 18 lb. shot, 6′ 6″. Brick walls from 2′ 8″ to 3′ 3″ thick; and rubble walls from 3′ 3″ to 3′ 10″ will resist field-guns. For forming the parapet under peculiar circumstances of difficulty the engineer will avail himself of every fitting substance which may be at hand; such as bags of wool, mattresses, fire-wood, manure heaps, as well as fascines, either by themselves or packed in gabions. Of these latter substances the resistance is not great, the penetration in wool being double that in rammed earth, and the strength of fascine works being rapidly diminished by the speedy fracture of the branches when exposed to a sharp fire.

With these data it will be easy to regulate all the dimensions of the parapet, the height of its crest, or the relief of the work, having been first established. Thus the plane of the banquette or step on which the men stand, when firing over the parapet, should for convenience be 4′ 3″ below the crest, and on no account should exceed 4′ 6″. The breadth or tread for a single rank should be 3′, for a double rank 4′ 6″; the surface should slope backwards 2 or 3 inches in the 3′—3 or $4\frac{1}{2}$ inches in the 4′ 6″, so as to discharge water freely and keep the banquette dry; the base of the interior slope of the banquette up which the men mount should be twice its height; if the height of the parapet exceed the normal height, it will be desirable to form two treads or steps to the banquette, the lower about seven feet below the crest, so that one rank of men may stand there whilst reloading the muskets of those in advance of them; or, to adopt steps with a rise to each of 1′, and a tread of 1′ or $1\frac{1}{2}$″, sloping slightly to the rear, by which arrangement the necessary excavation of the ditch will be diminished, and less of the interior space occupied. The interior slope of the parapet should be 1′, or a base of 1′ to 4″ of the height, and should never exceed a slope of 1 to 3—the superior slope or *plongée*, of the parapet, by which the fire is directed towards the point on which it is to act, should not be less than $\frac{1}{9}$, nor more than $\frac{1}{4}$ of its thickness, and in service is generally made $\frac{1}{6}$; but as the increase of the slope facilitates the destruction of the crest, it should be kept as small as possible; and it is usual on the continent to retain the angle of the crest as a constant quantity, at 100°, and hence to increase the base of the interior slope as the plunge increases, and *vice versa;* but this is not satisfactory, since the height of the soldier's shoulder remaining constant, whilst the direction of the prolongation of the line of plunge varies, the fire will not be always in the true direction; and it seems therefore preferable to keep the base of the interior slope as small as possible, and to make the top of the parapet at the crest horizontal for one or two feet, commencing the plunge at that point, and bringing it inwards in proportion to the increase of plunge. This flat space will facilitate the use of sand bags (bags filled with earth), which are sometimes so arranged on the crest of the parapet as to form loopholes for the musketry, whilst they add to the cover of the men; the base of the exterior slope of the parapet is equal to its height, in earth of a medium tenacity, so as to form an angle of 45°; and in some particular cases where the materials would naturally stand at a steeper slope, it may be made $\frac{2}{3}$. The bases of the slopes of the scarp and counterscarp of the ditch, as being cut in undisturbed ground, need not exceed $\frac{1}{2}$ of the depth as a general rule, though occasionally in very loose ground the slopes will require to be as gradual as in the exterior slope, or slope of made ground, in order to insure stability. Where steeper slopes are deemed indispensable, the earth must be supported in place by a retaining coating (or wall) called a revetement, which may be formed of *fascines* (long cylindrical bundles of faggots), hurdles, sods, planks, clay puddling, and, in interior works, of sand bags. The base of the interior slope of the glacis should be equal to its height, and the exterior slope have a plunge of 1 foot in 12. The command of the crest of the parapet over that of the glacis should be such that an assailant, having arrived on the crest, should not be able to fire into the interior of the work: a condition which requires a command over the glacis of $5\frac{1}{2}$ feet, so that with a parapet of 7 feet high the *maximum* height of glacis would be $1\frac{1}{2}$ feet. The minimum height of the glacis is determined by another condition, viz., that the fire from the parapet should be in a plane not more than 2 feet above the surface of the glacis; and in no case should the plunge or slope of the glacis be greater than that of the parapet. An advanced glacis is sometimes adopted either for rendering the cover more effectual, or to occupy a favourable line for first opposing the progress of the enemy. Fig. 21 shows this arrangement, g, g' being the first or ordinary glacis, and g^2, g^3 the second or advanced glacis. The slope of neither glacis should be such as to withdraw the assailants from the grazing fire of the parapet, and if it be not possible to extend the slope of $g^2\,g^3$ so far as to keep it in the prolongation of the line $C - g^2$, it should be at least so arranged that no point of the slope should be more than 2 feet below that line or the plane

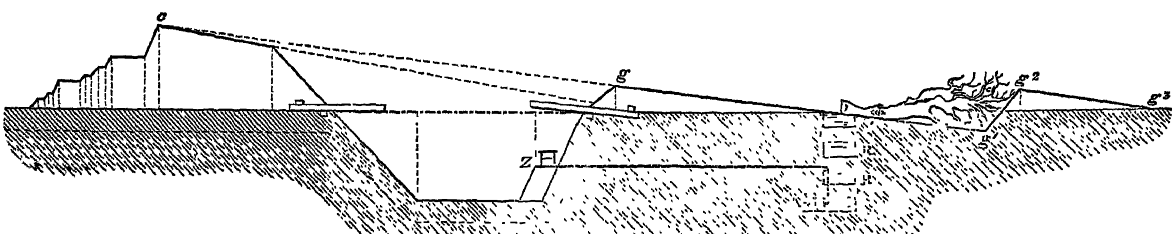

Fig. 21.

corresponding to it, namely, the plane passing through the crest of the parapet and the crest of the advanced glacis. To form the advanced glacis, the slope at g is prolonged below the surface of the earth to g', the excavation supplying material for the raised glacis. When it is intended that the defence of this advanced glacis shall be derived solely from the parapet, either an abattis or rows of stakes may be placed immediately behind it, so as to stop the advance of the enemy when at the point of maximum exposure, but such glacis may often assume the character of successive intrenchments, and be defended with vigour and success. This figure will be again referred to when treating on defence by mines. The height or relief of construction of the parapet having been determined by the amount of cover required, and the thickness by the nature of projectile expected to be brought against it, the whole profile or section has necessarily been completed on the principles pointed out, and the bulk, therefore, of earth contained in any portion of the parapet will be equal to the area of the mean or average profile multiplied by the length of that portion. Now, this earth must be obtained from the ditch, and hence the dimensions of the latter depend on those of the former,

whilst at the same time the volume of any portion of the excavated ditch will also be equal to its mean section multiplied by the length of that portion. If, then, P represent the area of the mean section of this portion of the parapet, D the area of the mean section of the corresponding portion of the ditch, and L the length of this portion, LP should be $=$ LD, providing the earth of the excavation were of the same bulk as after it; but such is not the case, and after having been broken up from its previously closely packed condition, it is found that the "remblai" or earth built up exceeds the "deblai," or earth excavated by a co-efficient varying with the nature of the soil, being in sandy soil nearly 0. Thus if $\frac{1}{m}$ represent the coefficient, it is in sand 0; in earth of medium tenacity $\frac{1}{12}$; and in very strong and naturally compressed earth $\frac{1}{6}$; so that to render the earth of the ditch just equal to that of the parapet, the above equation should be $LP = L\left(D + \frac{1}{m}D\right)$ and $P = D + \frac{1}{m}D$, or $D = \frac{m}{m+1}P$. As, however, the earth resulting from this excess, even allowing for the greater length of the ditch in polygonal works, will be required for forming the glacis, or for making up the banks in the salient called "barbettes," and intended for raising guns sufficiently high to fire over the parapet, the dimensions of the ditch may be safely estimated without reference to the excess, as follows:—

Let x be the breadth of the bottom of the ditch, and y its depth; and let the sum of the bases of the slopes of the scarp and counterscarp be represented as a function of the depth by the fraction $\frac{r}{s}y$; then $x + \frac{r}{s}y$ will be equal to the breadth of the ditch at top, and $D = \frac{y}{2}\left(x + x + \frac{r}{s}y\right)$ whence $x = \frac{D}{y} - \frac{r}{2s}y$, and $y = \frac{s}{r}\left(-x + \sqrt{x^2 + \frac{2r}{s}D}\right)$. Now as the defensive object of the ditch requires that it should be both deep and wide enough to form a decided obstruction in the way of an enemy, the width ought not to be less than 18 feet, whilst the depth should have no other limit than that arising from the difficulty of raising the earth which makes 12 feet about the maximum. Taking then $y = 12, \frac{r}{s} = \frac{3}{2}$, and $D = 108$ superficial, $x = 9 - 9 = 0$, and the width of the ditch therefore $= \frac{2}{3}$ of $12 = 18$; the ditch being triangular.

Assuming a profile area of 70, corresponding to a parapet 7 feet high and only 6 feet thick, and making $x = 0$ for a triangular ditch, $y = \sqrt{\frac{2s}{r}D} = 9'\ 7''$, and the width of the ditch $= 14\frac{1}{2}$ feet: with a profile area of 116 feet corresponding to a parapet $7\frac{1}{2}$ feet in height and 12 feet thick, the depth of the ditch, if triangular, is $12\frac{1}{2}$ feet and its width $18\frac{3}{4}$; so that this profile appears about the maximum for a triangular ditch with a profile area of 163 feet, corresponding to a parapet 8 feet high and 18 feet thick. With a banquette $4\frac{1}{2}$ feet wide a triangular ditch would give $y = 14\frac{3}{4}$ feet, so that such a form would be inconvenient; but taking $x = 4$ as the width of the bottom of the ditch, y or the depth becomes $12'\ 4''$, and the width of the top of the ditch $22\frac{1}{2}$ feet—a very well-proportioned ditch.

In the preceding cases the base of slope of the scarp has been assumed as equal to its height, and that of the counterscarp slope as half the height. Should the nature of the soil be such as to require the base to be equal to the height in both scarp and counterscarp, $\frac{r}{s}y = 2y$; and where the soil is sufficiently firm to admit of a base of one-half in both, $\frac{r}{s}y = y$. In the first of these cases even the large profile area last named may be made triangular with a depth of $12\frac{1}{2}$ feet, and breadth of 25; and in the second a triangular ditch is inadmissible even with an area of 116 feet, as it would require a depth of more than 15 feet; and it could only be used with profile areas up to 85 superficial feet, for which a depth of 13 feet would be required. Before leaving this subject, a few words may be said respecting the "berm." The most effectual scarp in respect to defence is that which forms one continuous plane with the exterior slope, or at least which commences immediately where the other ends, as the absolute relief of the parapet is therefore made a maximum, and there is no berm; but in many cases it would be imprudent to carry the parapet up to the edge of the scarp, as the latter might be easily injured and occasion a fall of part of the parapet, and further, the difficulty of construction would be greatly increased by having no intermediate stage between the bottom of the ditch and the top of the parapet. The "berm" or step between the top of the scarp and bottom of the parapet is made from 2 to 4 feet according to the nature of the ground, and it then becomes possible in most cases to increase the slope of the scarp to a base of $\frac{1}{2}$ or $\frac{2}{3}$, at least to such a slope as shall bring the prolongation of the exterior slope of the parapet to the base of the scarp. The berm is encumbered with such obstacles as shall prevent an enemy from making it a halting place (see fig. 12). The slope of the counterscarp is usually $\frac{1}{3}$, $\frac{1}{2}$, or $\frac{2}{3}$, when that of the scarp is $\frac{1}{2}$, $\frac{2}{3}$, or 1; and it should be added that the bottom of the ditch ought always to slope on each side towards the centre, so as to carry off the water, and that it should be so arranged as to prevent the enemy from collecting together, and reforming his men in the ditch which in all cases of simple lines, without flanking defences, he would do were the bottom left free from obstructions.

APPLICATION OF THE PARAPET IN COMBINED OR RECIPROCAL DEFENCE, CONSTITUTING PARAPET OR FIELD FORTIFICATION.

The parapet has been hitherto considered principally in its character as the simplest element of defensive works, affording at once protective cover to the soldiers behind it and an obstruction to the advance of their enemies; but it is now time to consider the manner in which this parapet may be so arranged as to constitute a series of defensive and mutually defending works. Were the antiquity of an invention to be estimated in reference to an epoch in the social history of any race of mankind rather than to a point in absolute time, there can be little doubt that earth-works would, as might be naturally expected, claim the priority over all other modes of defence. In North America vestiges of circular intrenchments, as well as of works of a more complicated outline, have been discovered, the antiquity of which is unknown; and even now, when a small party of the aboriginal inhabitants have been suddenly encountered by a much greater number of a hostile tribe, they have been known to excavate a hollow space in the ground, and, throwing out the earth, to form around them a circular intrenchment, in which they have defended themselves to the last. In Ireland its ancient inhabitants have left similar relics of their earthen defences, as in Great Britain the Romans have left of theirs; but the further consideration of the value of earthen works, when adopted in the defence of extensive fortresses, will be resumed in a future passage, and they will be considered here only in connection with the arrangements adopted by an army in the field for its own immediate security.

The art of constructing all kinds of temporary works in the field for this purpose is usually called field fortification, a name here replaced by that of parapet fortification. An army intrenched, or fortified, in the field, produces, in many respects, the same effect as a fortress; for it covers a country, supplies the want of numbers, stops the advance of a superior enemy, or, if he chooses to risk a battle, obliges him to engage at a disadvantage. "In a war of march and manœuvre," says Napoleon, "if you would avoid a battle with a superior army, it is necessary to intrench every night, and to occupy a good defensive position. Those natural positions which are ordinarily met with are not sufficient to protect an army against superior numbers without recourse to art. Those who proscribe lines of circumvallation, and all the assistance which the science of the engineer can afford, deprive themselves gratuitously of an auxiliary which is never injurious, almost always useful, and often indispensable. It must be admitted at the same time that the principles of field fortification require improvement. This important branch of the art of war has made no progress since the times of the ancients. It is even inferior to what it was two thousand years ago. Engineer officers should be encouraged in bringing this art to perfection, and in placing it on a level with the rest."[1]

Whenever Napoleon had time and occasion for strengthening his position by field-works, he acted upon the principles recommended in the above extract, as almost all his predecessors had done. In the wars which followed the revolution of 1688, in those of Queen Anne's reign, and during the Seven Years' War, we find the commanders of each period, William III., the Duke of Marlborough, Marshal Villars, Marshal Saxe, Frederick II., and Marshal Daun, practically exemplifying their conviction of the great utility of field-works. A few redoubts saved Peter the Great at Pultowa, and enabled him to gain a decisive victory over his formidable antagonist; and at Borodino, some slight open field-works, thrown up by the Russians, caused the French great loss, and rendered too costly to be of almost any avail the victory which, by incredible efforts of gallantry, they gained. It has been argued by some, against intrenchments and field-works, that they have oftener been carried than successfully defended, and that hence incommensurate importance has been attached to them. But it should be remembered, on the other hand, that victory in such circumstances has generally been purchased at an expense which rendered it in effect equivalent to defeat; and that a practice which the greatest commanders of ancient and modern times have approved and followed cannot be one of doubtful utility. At Austerlitz, where the contending armies were nearly equal, Napoleon was preparing to superintend the construction of intrenchments when he found himself called upon to receive battle; and in Portugal, the Duke of Wellington showed to what importance the art of the engineer might be turned for influencing, not merely the fortune of a campaign, but the fate of a cause. The lines of Torres Vedras, which formed the *ne plus ultra* of the powerful French army under Massena, and from which the tide of war was rolled back broken into Spain, were perhaps the most remarkable works of the kind ever constructed.

"Lisbon," says Sir John Jones, "being situated at the extremity of a peninsula formed by the sea and the Tagus, it is plain that if an army be so posted as to extend across the peninsula, no enemy can penetrate into the city without a direct attack on the army so formed. It was on this principle that the lines covering Lisbon were planned by Lord Wellington. Nature drew the rude outline of a strong defensive position, and art rendered it perfect. A tract of country thirty miles, extending from the mouth of the Zizandra on the ocean, to Alhandra on the Tagus, was modelled into a field of battle; mountains were scarped perpendicularly, rivers dammed, and inundations formed; all roads favourable to the enemy were destroyed, and others made to facilitate the communications of the defenders; formidable works were erected to strengthen and support the weak parts, whilst numerous cannon, placed on inaccessible points, commanded the different approaches to them, and gave an equality of defence to the whole position."[2] These lines were not continuous and connected works; they consisted of independent forts, redoubts, flêches, redans, batteries, &c., so placed as to command and enfilade every approach, and to support each other by a cross or a flanking fire. The first line occupied a front of twenty-nine miles between the sea and the Tagus; and by means of telegraphs intelligence could be conveyed from one extremity to the other in a few minutes; whilst the troops were disposed in masses in the rear of the works ready to move upon any point that might be attacked, by interior communications shorter than any by which the enemy could advance. "The aim and scope of these works," says Colonel Napier, "was to bar the passes, and to strengthen the fighting positions between them, without impeding the movements of the army. These objects were attained; and it is certain that the loss of the first line would not have been injurious, save in reputation, because the retreat was secure upon the second and stronger line, and the guns of the first were all of inferior calibre, mounted on common truck carriages, and consequently immoveable and useless to the enemy."[3] Both lines occupied a front of fifty miles, on which there were erected one hundred and fifty forts, mounting in all about six hundred pieces of artillery.

Before this formidable position, defended by a double line of works, and by an army massed and ready to move upon any point by interior communications, the French remained five months, wasting their numbers and resources; until at length, finding it utterly impracticable to force any part of even the exterior line, they were obliged to retire from Portugal, closely followed and harassed by the army which they had previously driven out of Spain. Yet though the lines of Torres Vedras were thus perfect in themselves, and though one of the ablest of the French generals and a veteran French army were foiled before them, it is not meant to refer to this system of separate field-works as a model to be followed on all occasions; for whilst the old method of covering a considerable front by a continued line of regular bastions and curtains has been universally condemned by modern engineers, it is nevertheless certain that there are situations where a partial application of continued lines may be most judiciously made. In fact, it is not by any fixed rule, but from the nature of the ground and of the position to be defended, that the species of works calculated to be most useful should, in every case, be determined.

At this point it is necessary to remember, that in any protracted defence, or, indeed, in any efficient defence, artillery must be combined with musketry; and hence that in the arrangement of lines provision must be made for the

[1] *Military Maxims of Napoleon.*

[2] *War in Spain*, p. 124. The French army which invaded Portugal under Massena consisted of three corps, under Marshals Ney and Junot and General Regnier, amounting in all to 66,000 infantry and 6000 cavalry, besides a strong body of the imperial guard, which crossed the Pyrenees after the invading force had commenced its march from the neighbourhood of Salamanca. The force collected to oppose this threatened invasion did not exceed 48,000 infantry and 3000 cavalry, of which about a half was composed of Portuguese levies, yet untried in any general action, and of which a very unfavourable opinion still continued to be entertained. In point of numbers, and still more in the composition of their army, therefore, the French had a decided superiority; but all their advantages were neutralized by the defensive position of Torres Vedras.

[3] *History of the War in the Peninsula*, vol. iii.

Artillery in defence.

use of cannon. When it is possible so to place guns that they may bear on definite lines or points, such as a natural ravine, an artificial road or other communication, a line of abattis or other obstacle, the ditch, the scarp, the glacis of some portion of the works which must be passed in advancing to the attack, or the point in front of a salient, it is desirable that they should be preserved in that position, ready to act at the right moment; and hence it is that they should not fire *over* but *through* the parapet, and the opening made in the parapet for this purpose is called an "embrasure." It is more usual to make these embrasures in field-works shortly before they are required to be used, so that the parapet may be made quite solid and firm in the first instance, and without the trouble which attention to the preservation of the opening would necessarily occasion in construction. In order to obtain command over a glacis constructed in reference to the exterior slope of the parapet, and yet to insure cover, the parapet must be raised so as to cover the men serving the gun placed on the usual barbette terreplein—(see fig. 22)—which would other-

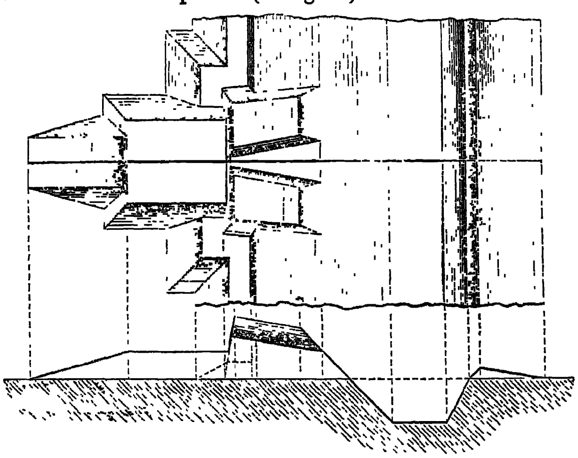

Fig. 22.

wise fire over the ordinary parapet, and not, as here represented, through an embrasure. The section shows by dotted lines the difference of level between the terreplein of the gun and the plane of the banquette of the ordinary parapet. The dimensions of the embrasure are determined on simple principles—the interior opening or neck is made only 20 inches wide to avoid unnecessary exposure of the men, and the exterior opening is made half the thickness of the parapet, measured along the ridge line of the exterior slope; (see fig. 23). When the guns are intended to flank the ditches, or to fire along a ravine, or the crest of a natural scarp, which fulfils the function, as an obstacle, of the ditch, the embrasures are cut in the ordinary parapet, and the guns stand on the natural terreplein of the work, as stated above.

The portion of parapet left below the embrasure is called genonillère, from genon, the knee; and for field-guns should be $3\frac{1}{2}$ feet high; the portion between two embrasures is called merlin, from the Italian *merlone*, a battlement; the bottom of the embrasure is called its sole; and in the same manner as has been suggested in respect to the superior slope of the parapet, it should be horizontal for the first four feet from the neck or interior opening, and then slope downwards as much as may be necessary to attain the amount of depression required in firing. The direction of the embrasure depends on the intended direction of the line of fire, and is either perpendicular to the crest as at *a'b*, or oblique as at *mn* (fig. 23). In the latter case, should the obliquity be very great, or exceeding 70°, the crest of the parapet must be made re-entering, as at *oi*, so as to strengthen it near the neck, and to enable the gun carriage to be brought up square to the parapet; *o* P should be at least 8 feet; the sides of the embrasure are called cheeks, and should be rivetted either with planks, with sods, with fascines, or with gabions (hollow cylinders made of wicker

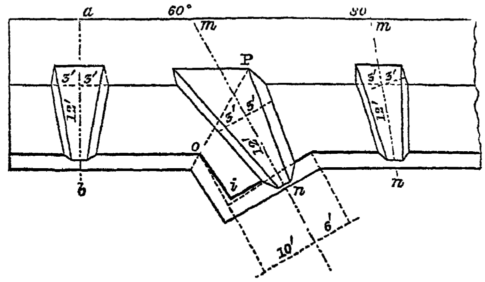

Fig. 23.

work, and filled with earth). In fig. 24, on the left, at B, a direct embrasure is seen cut straight through the parapet: and on the right at A, an oblique one, both being intended to enfilade the ditches opposite them; and it will be observed that, from the obliquity of the right-hand embrasures, the interior of the work becomes so much exposed, that a traverse, T, behind the embrasure, becomes necessary. Barbettes are also shown in this figure—one at the salient at D for four guns, and another at C, perpendicular to the

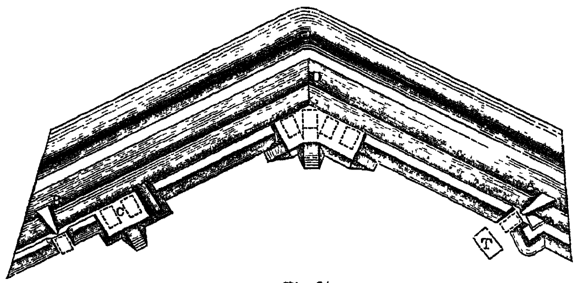

Fig. 24.

face or branch, for two. The terreplein of the barbette should be from 3 to $3\frac{1}{2}$ feet below the crest of the parapet; its height from front to rear from 18 to 20; and its breadth, for a single gun, from 15 to 18, according as it may be necessary to fire more or less obliquely; and a breadth of 12 to 15 feet should be added for every additional gun. To add to the lateral sweep or range of the gun, without diminishing the banquette, or, in other words, the musketry fire, the barbette may be made wider in the rear than in front. In proportion to its magnitude should be the number of "*ramps*," or slopes of approach; as, for example, at C only one, at D three. The ramps should be from 8 to 9 feet wide, and their slope should have a base equal to 4 times the height of the barbette. The lateral slopes of the barbette and of its ramps should be revêted whenever it is possible to obtain sods, fascines, or hurdles, in order to economize space in the work, as the base of the slope may be then reduced to $\frac{1}{4}$ or $\frac{1}{6}$ the height; more generally they are left unrevêted, with slopes of $\frac{1}{6}$. The terreplein of the barbette may require, as at C, to be covered in flank by a traverse. The mode of constructing a barbette in a salient is exhibited in fig. 25 *a*.

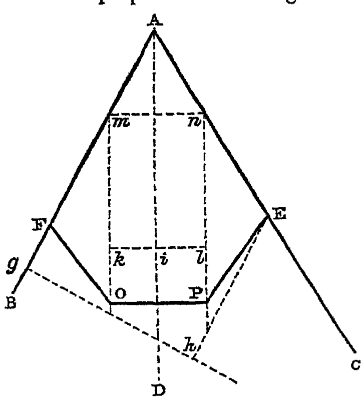

Fig. 25 *a*.

At any point *g* of the face AB raise a perpendicular *gh*, either 18 or 20 feet in length, to include the amount of re-

coil; at the point h thus determined raise a perpendicular to gh and prolong it to its intersection with the other face AC at E, then setting off AF on the other face equal to AE. On the capital AD, set off a double perpendicular at any point i, prolonging it both ways, and making ik and il each at least equal to $4\frac{1}{2}$ feet to represent the half breadth of the platform on which the gun-carriage is intended to stand and move; through the points k and l draw parallels to the capital, cutting the faces on the points m and n; join m, n, and parallel to the line mn draw the line OP at 18 or 20 feet distant from it, when m n P O, form the platform. Join FO and EP, and AEPOF will represent the contour or trace of the barbette. The manner in which the crest of the parapet is formed above the salient A, and the mode in which the firing may be effected in directions perpendicular to the faces, as well as in the direction of the capital, is shown in fig. 25 *b*.

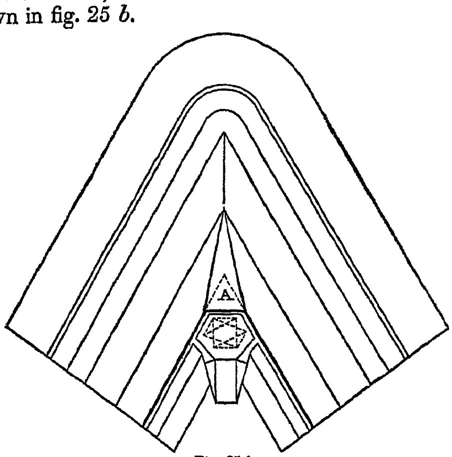

Fig. 25 *b*.

In the case of a partly sunken parapet, in which the portion above the banquette is raised above the plane of site, and the portion below the banquette excavated as in fig. 26, the barbette constructed in the hollow portion will enable the gun to fire over the parapet; and it should be protected by forming a bonnetted embrasure, which may be sometimes made large enough, as here represented, to hold two guns. It need scarcely be added that an engineer ought to be ready in adapting any of the expedients here briefly noticed to the circumstances of any particular case,

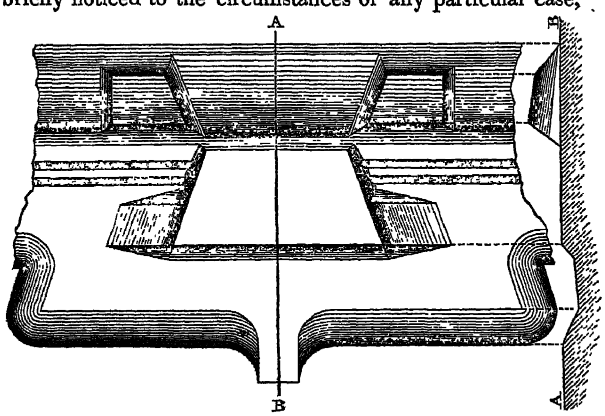

Fig. 26.

and that a mind stored with resources against any possible casualty is one of the highest endowments of a really good officer. It must be obvious indeed that even a limited knowledge of the art of war opens a wide field for the exercise of the talents and resources of engineers in field fortification; but the possession of a military coup-d'œil, or of that intuitive judgment which comprehends at a glance the true bearing or character of objects as well as events, is necessary to enable them to convert theoretical stores of information to the best practical uses. In passing through a country, it requires an experienced eye to seize quickly on whatever it presents calculated to prove advantageous or disadvantageous to an army destined to attack or defend it; to appreciate the value of villages, stone-inclosures, and broken ground; to know where to dam up rivers, to scarp heights, to form abattis, trous-de-loup, and other obstacles; to select the best situations for field-forts and redoubts, and the best sites for batteries; and to arrange all the defensive means employed, with reference to the number of troops destined to act upon the different parts of the line, so that the movements of the defenders may not be obstructed or retarded, and the communications throughout may be short and easy. The variety of ground, however, upon which military operations are for the most part carried on, precludes the possibility of laying down fixed rules in regard to this subject; the accidents of ground, and the peculiar circumstances of each individual case, must, as already observed, determine the extent and description of the works to be constructed, as well as the obstacles most proper to be formed for retarding, if not obstructing, the advance of an enemy.[1]

At the same time, though the observance of fixed rules be impracticable, general principles are of universal application; and certain maxims founded upon them hold equally good in regard to the construction of field-works as in that of the more complicated works of a fortress. These are, *first*, that the works to be flanked must never be beyond the range of the projectiles used in the works flanking them, or in other words the length of the lines of defence never exceed the effective range of musketry; *secondly*, that the angles of defence should be about right angles; *thirdly*, that the salient angles of all works should be as obtuse as possible; *fourthly*, that the ditches should be as efficiently flanked as is possible; *fifthly*, that the relief of the flanking works must be determined by the length of the lines of defence; and, *sixthly*, that in the construction of field-works, reference should not only be had to the direct and immediate obstacles which the work itself is calculated to present to the enemy, and the positive effect of its fire on the approaches to it, but the relative value of the work should likewise be considered with respect to the support it can receive from or give to other works. These principles or maxims are of invariable application.

Field-works are either open at the gorge as in fig. 1, 2, 3, 4, Pl. CCLIX, or inclosed all round as in fig. 5, 6, 7; namely—

Redans, or simple heads	fig. 1.
Double redans, or queues d'hironde	fig. 2.
Tenailled heads	fig. 3.
Bastioned heads	fig. 4.
Redoubts	fig. 5.
Star-forts	fig. 6.
Bastioned forts	fig. 7.
Lines à crémaillières	fig. 8.
Lines of redans	fig. 9.
Lines of tenailles	fig. 10.
Lines of bastions	fig. 11.
Lines of demi-bastions	fig. 12.
Lines broken or with intervals	fig. 14.

The first class are of the simplest kind of field-works, and serve as a mere cover in front of avenues, bridges, (see fig. 13), causeways, and the like; but being quite open at the gorge, they are only suited for defence when their extremities rest on rivers, or obstacles which prevent their being turned, or when within the full sweeping fire of works

[1] Shaw's *Course of Field Fortification*, p. 9, *et seqq*. Much assistance has been derived from this useful work in the compilation of this article, as well as from the admirable Treatise on Field Fortification by Fischmeister, translated by Rieffel into French, the figures of

in their rear. To increase the strength of a *redan*, its faces are sometimes broken into a kind of flank, as in fig. 1, Pl. CCLIX. In the *double redan*, or *queue d'hironde*, fig. 2, the re-entering faces defend each other; the *tenailled heads* are used in situations which require a greater extent of front; and the *bastioned heads* are also employed in similar circumstances. See fig. 3 and 4.

Redoubts are works closed on all sides; they are constructed of a square or polygonal figure, but most commonly square, as, when of this form, each front can furnish a strong perpendicular fire. Provision should be made for defending the ground before the angles, which, however, are sometimes rounded or cut *en crémaillière*, so that a fire may be delivered from them. See fig. 5.

Star-forts were proposed in order to remedy the defects of redoubts having the ground before them undefended by a flanking fire, so that a cross fire might be delivered from the adjacent sides. But according to Jomini, "star-forts are the very worst description of fortification; they cannot have flanks, and the re-entering angles take so much from the interior space that it is impossible to place troops and artillery in them sufficient for their defence:" an opinion confirmed by the practice of Sir Richard Fletcher and Sir John Jones in the construction of the lines of Torres Vedras, where the trace of the redoubts was made subservient to the conformation of the ground, to the object in view, and to the protecting them as much as possible from the fire of the enemy's position.

In *bastioned forts*, fig. 7, the flanking defence obtained for the ditch is nearly perfect. As bastioned forts are only constructed in cases of great importance, no labour or expense should be spared in the formation of such works.

Forts with demi-bastions, fig. 12, are objectionable, as the ditches are only defended by an oblique fire of their faces. The parapets of all these works should be of sufficient thickness to resist the fire of the heaviest guns that can be brought against them. In some cases, however, the parapets need only be strong enough to resist the fire of light field-guns, whilst in others it will be sufficient if they serve as a cover to the men within them against musketry. The latter kind is generally that which is thrown up in an evening after taking up a position, and which, if the army does not move next day, it may be considered as necessary to strengthen in some parts, according to circumstances.

Continued lines, or connected works, are resorted to in order to inclose the front, or to connect important works or forts. The most simple tracing is that of redans joined together by curtains (fig. 9); but as the ditches of these curtains can only be defended by an oblique fire from the faces of the redans, this defect may be remedied by breaking the curtains so as to form nearly right angles with the faces of the redans, in which case they are called *lines of tenailles*.

Lines en crémaillière have long faces, with flanks perpendicular to these, in order to defend their ditches. When the faces can be directed towards ground upon which it is impracticable to establish enfilading batteries, the construction is considered as good.

Bastioned lines form the strongest trace which can be given to continued lines, when the ground will admit of its adoption. A perfectly regular trace is only suited for level ground. The ditches in field-works are often sloped *en rampe* towards the adjoining flanks, in order that the *deblai*, or quantity of earth excavated, may not exceed the *remblai*, or quantity contained in the mass of the rampart or parapet, a circumstance which often occurs in field-works, where there is seldom any rampart, and only cover sufficient for the defenders.

Lines with intervals. Fig. 14 shows the general trace of lines of this kind. The salient works should never be beyond the range of musketry from the re-entering works, and the angles of defence between the two lines should be as near as possible to right angles.

Têtes-de-pont, or *bridge-heads*, are works generally open at the gorge, and whose flanks rest upon a river, in order to cover one or more bridges. The best situation for these works is the re-entering sinuosity of a river. As tetes-de-pont, fig. 13, are usually constructed for the purpose of enabling a retiring army to cross a river in order, and to check an enemy pressing upon it, the tracing and profile should be such as to secure a double advantage to the greatest extent possible. In Sir Howard Douglas's able work on the Construction of Military Bridges will be found much valuable scientific information upon this important subject.

The obstacles which are usually added to field-works, in order to render the approaches more difficult to the enemy, such as *palisades, barriers, abbatis, trous-de-loup, chevaux-de-frise, harrows*, and *crows'-feet*, have been already noticed.

For *the defence of open towns and villages*, the following methods, recommended by the French minister of war in 1814, are considered as the best that have yet been suggested: "To admit of a town being advantageously intrenched, it is necessary that it should not be commanded within any short distance, that the houses should not be of a construction easily set on fire, and that its extent should not be out of proportion to the means and time at the disposal of the defenders. The first thing to be done is to clear the approaches to the town, by levelling houses, hedges, shrubberies, and whatever may favour the assailants. Wood ought to be cut two feet from the ground, that it may serve to impede the advance of the enemy without masking the fire of the defenders. The next object is to form or complete the inclosure round the town. For this purpose advantage is taken of buildings, walls, and fences applicable to the defence. The openings which remain must be closed by palisades, stockades, or ditches strengthened by abattis. All streets leading out of town must be barricaded. The barricades must be sufficient to resist field artillery, and high enough not to be easily got over; and they ought to be flanked by loopholing the neighbouring houses. When pressed for time, carts filled with dung and the wheels taken off, sand-bags, bales of wool or cotton, and furniture taken from the neighbouring houses, all form good barricades. If there should be any old castle, church, or large substantial building, it should be converted into a keep, by blocking up useless entrances, loopholing walls, and surrounding them by a ditch or abattis. If a town is situated near a stream or river, by which part of it may be covered by inundations, this should never be neglected."

Villages are intrenched on similar principles, and being generally surrounded by gardens with live hedges, the latter may be made use of in forming the lines of defence. If there should only be sufficient troops to defend part of a village or town, a part only should be intrenched and separated from the rest by means of carts and barricades. If there are very few houses, it may be necessary to confine the defence to the church or churchyard, which may in all cases serve as a sort of keep.

The destruction of bridges. Nothing is of greater consequence to a retiring army than to be able to destroy the bridges in its rear, in order to retard the advance of the enemy. Its safety, nay even its existence, may depend upon the success with which this operation is performed. In order to destroy a stone-bridge, a trench in the form of a cross is made in the crown of the arch, the branches of which are about ten feet in length, and sunk to the top of the arch-stones. One hundred and sixty pounds of powder are placed in each cut or trench for an arch three feet thick, strong planks are then laid over the powder, and the whole being well covered with rubbish, the fire is communicated by means of a saucisson or long powder-hose. Stone bridges are also destroyed by simply cutting a trench about eigh-

teen inches deep across the crown of the arch, and placing in it 345 pounds of powder covered in the manner just described. This quantity has been found sufficient to destroy semicircular arches of twenty-five feet in span, and three feet in thickness at the key. Wooden bridges may be destroyed in different ways; they may be pulled to pieces, burned, or blown up. When there is time to take them to pieces, they are unspiked, and the timbers so separated that they may be speedily removed. The best method of burning such bridges is to tar them, and to cover and surround them with fascines or tarred brushwood. When it is necessary to blow up wooden bridges, this may be effected by means of 220 pounds of powder suspended under the superstructure, and fired in the manner above described.

A *ford* is rendered impassable by throwing in large stones, by sinking boards with spikes standing upright in them, by scattering in it crows' feet, or by placing harrows taken from the neighbouring farms. A low rubble wall may be formed across, so as not to be perceptible above the water; strong stakes may be driven into the bottom, and trees fastened to them; waggons loaded with stones, and the wheels taken off, may in like manner be employed; not to mention a number of other things which may be easily found, and which will answer the purpose equally well. The rendering a ford impassable by such means is only second in importance to the destruction of a bridge, when the enemy whose progress it is desired to retard has either no pontoon-train at all, or has outstripped it by the rapidity of his advance. In this way, much valuable time may be gained on the one hand and lost on the other.

In order to bring a retiring army into the position when the business of intrenching itself would naturally begin, some portions of the subject of defence have been in part anticipated in the preceding passages, and the main line of argument will be now resumed.

The essential characteristic of all works formed of earth is, that the musketry fire, on which the defence must mainly depend, being discharged over the crest of the parapet, the line of fire will be nearly in the plane of the superior slope of the parapet, and perpendicular to the line of its crest; and hence opposite a salient angle, as in the redan, fig. 27, there

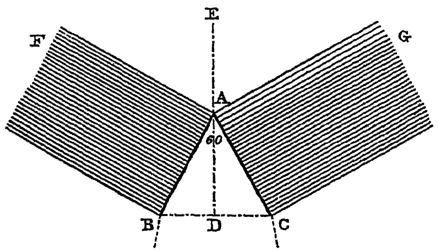

Fig. 27.

will be a large space of ground at A, in this case extending over $180° - 60° = 120°$, not defended by the fire of the work itself, and which is called a dead angle. Opposite re-entering angles, on the other hand, the defect is of a different kind, as the plane of the superior slope or plane of fire passing so high above the foot of the scarp, necessarily leaves it unseen and unprotected, notwithstanding that the two lines theoretically flank each other. The object, therefore, in arranging all field works for mutual defence should be so to regulate their reliefs that the line of defence should terminate at such a distance from the ground as to give an effective defence to the part of the work intended to be flanked. The redan may be considered the most simple form of *defensive* work, though a portion of straight parapet terminating by short returns at each flank, either in the form of epaulements or of regular parapets, may occasionally be combined with defensive works, and is an ordinary form of offensive work in batteries. The redan is open in the rear, and the line BDC is called the gorge—in this case a straight line—the two demi-gorges BD, CD coinciding in direction.

The lunette is a redan to which flanks or lateral wings have been added; and in form, therefore, it resembles a bastion. In Plate CCLIX., fig. 14, lunettes are shown so arranged that the faces of those in rear may flank the faces of those in front: but with respect to the distribution and arrangement of the works destined to form lines of intrenchment more will be said hereafter.

The tenaille is a work the reverse of a redan, as it consists of two lines forming a *re-entering* angle facing the exterior. It can, from its form, only be used in direct or approximate connection with other works which shall close up or cover the ends of its lines. Either alone or combined with redans it is very commonly used in continued lines of intrenchments. Plate CCLIX., fig. 9, represents a line of redans joined by straight lines, and fig. 10 a line of irregular tenailles, whilst the annexed cut, fig. 28, represents a normal

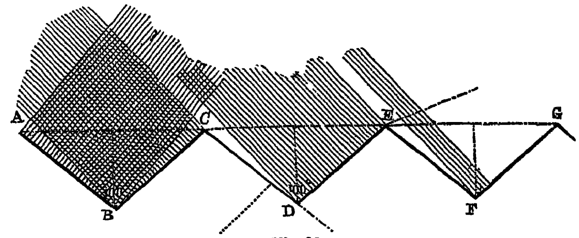

Fig. 28.

line of tenailles, of which the re-entering angles should not exceed 100°, and the sides are equal; and cut fig. 29, an

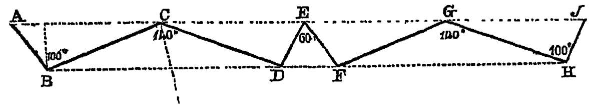

Fig. 29.

arrangement of tenailles, with irregular sides, by which a redan, as DEF, is interposed between every pair of tenailles. The line *en cremallière*, Plate CCLIX., fig. 8, is also derived from a combination of irregular tenailles, and is in many circumstances a very satisfactory arrangement. In selecting between these and other arrangements, including the bastion trace, Plate CCLIX., fig. 11, the engineer must be guided by his judgment on the nature of the ground and the special objects to be attained, and cannot therefore be bound by any rigid rules. A slight consideration, however, is sufficient to show that the combination of regular tenailles, in cut 28, is only applicable to ground in itself regular, an observation which applies to every strictly systematic arrangement in fortification. In almost every case the ground will be more or less irregular, and the works to defend it must be so also. When it is necessary to approach closely to a bank of a river or a ravine, the cremallière line, Pl. CCLIX., fig. 13, is the simplest and best, the short or flanking sides being so placed as to face the probable direction of approach, and next to that the combined redan and tenaille. Of open works, lunettes admit of the most scientific arrangement, as they can be so placed in lines with intervals as reciprocally to flank each other, and thus to form a line of defence very similar to a regular bastioned line. The employment, however, of works open at the gorge must be restricted to positions where the enemy can only approach in front, his advance in other directions having been rendered impossible either by other works, or by obstacles so arranged as to close that particular line of approach to an enemy. In every case it is desirable to take advantage of any peculiarities in the features of the country, and so to modify them as to produce such insurmountable obstacles as may relieve the minds of the defenders from apprehension of danger in that direction, and leave them at liberty to direct their attention more exclusively to the weaker points of their position; but in no case

should even the apparently inaccessible points be left unguarded, or rather unwatched, as an enterprising and skilful adversary will sometimes surmount difficulties which had appeared to others insurmountable. As such naturally defended points in a position can only be looked upon as exceptional advantages, it is evident that works left entirely open at their gorges would be liable to easy and frequent surprise, and therefore prove but imperfect instruments of defence. On this account it has been usual to prescribe as a rule that such works should only be left unclosed when within range of musketry fire from the defences behind them; but it is better to lay down as a fixed principle that in every case they should be secured at the gorge, as the power of driving an enemy out of the interior of such a work when taken is in reality of no value, as his object would not be to remain in its *interior*, but to turn its parapet to his own uses. The manner in which this is generally done is shown in fig. 30, which is a lunette se-

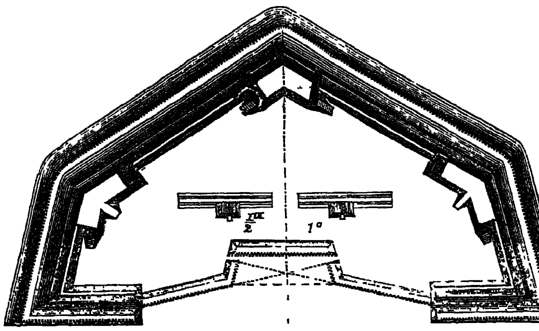

Fig. 30.

cured at its gorge by a loop-holed stockade, which is an obstacle effective against an enemy, and, at the same time, easy of destruction, should he succeed in temporarily obtaining possession of the works. Any of the obstacles previously described, such as abattis, &c., may be used for the same purpose, but they have the disadvantage of not covering the defenders of the work from the enemy's fire. An engineer in deciding between open works, such as those described, and close works, which will now be described, ought to take into consideration not only the circumstances of ground as regards the security of the work itself, but also the ease or difficulty with which support can at any moment be afforded to its garrison. Open works are not fitted for any position where they are likely to be left to their own resources, even for a moderately short time, as small bodies of men cannot be expected to stand firm against a vigorous attack from an overwhelming force, unless satisfied that support is at hand. Closed works, therefore, in which the parapet is continuous on all sides, can alone be relied upon under such circumstances; and even then the nature of the obstructions adopted in their construction should be such as to afford the garrison a reasonable confidence, that by a vigorous defence they may be able to hold the enemy at bay; for no general should expect to find in soldiers, as a body, that heroism which leads to self-sacrifice without hope. The easy capture of the redoubts at Balaclava, garrisoned by the Turks, is an illustration of this principle; for though it is possible that they might have been longer maintained by French or British soldiers, it would have been unreasonable to expect that their defenders should remain firm until overpowered and cut down by their assailants, which must have been the result had not a supporting force been at hand to relieve them. As general rules, therefore, it may be laid down, that in all detached works the mode and time of relief should be palpable to the garrison; the nature of the constructions such as to inspire confidence in the garrison as to its power of resistance for a reasonable time; and, above all, that the garrison of such works should be composed of the best, not of the worst soldiers.

Closed works may be either constructed without or with flanking defences; the first, which have only salient angles, being called redoubts, from the Italian *ridotto*, a place of rendezvous; the latter forts. Redoubts may be either formed as regular or irregular polygons of any number of sides, but the square redoubt is the most simple and the most generally used, see Pl. CCLIX., fig. 5. All such redoubts have the disadvantage of dead salient angles not having any flanking defence; and it is usual, therefore, to place the guns used in their defence, in the salients, so as to fire along the capitals or lines bisecting the salient angles, as well as the dead space in front of them. In like manner the sides should be made to front the probable line of approach, and as shown in one half of fig. 31, which represents a rectangular redoubt, the scarp is sometimes sloped gently down to the bottom of the ditch, and covered with abattis or other obstacles, which can then be seen and defended in front by direct fire. It is indeed impossible to repeat too often that the efficiency of defence in such works must mainly depend on the power of arresting the progress of the assailants just on those points where they will come under the fire of the defenders. The entrance to a redoubt should be made in the least exposed side, and be protected by a parapet traverse behind it, as in fig. 31, where an arrangement of palisades is shown by which the traverse may be connected with the other portions of the parapet, and the entrance be closed by gates or barriers as required. Other traverses may be also constructed in such works either for the purpose of defilade or for affording additional cover to the troops. They may be formed, when the work is sufficiently capacious, of long parallel epaulements, with a space between them, which may be even covered over or blinded when it is likely that

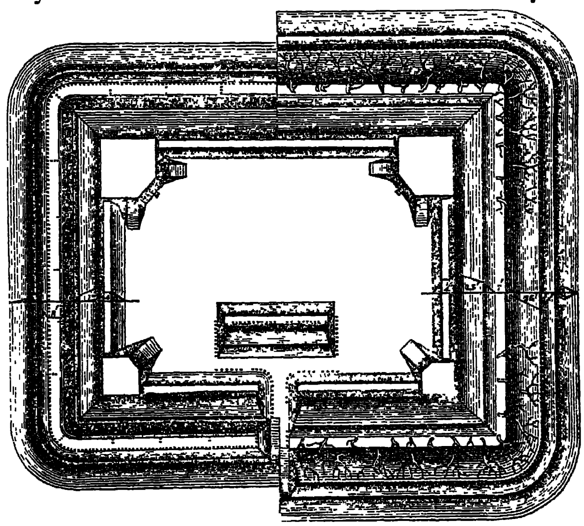

Fig. 31.

the work will be held for a considerable time, and in consequence that a more secure and comfortable lodging will be desirable for the garrison. Magazines for ammunition may be also constructed either against or in such traverses; and fig. 32 (see next page) represents, in plan and section, one which, formed behind a gabion traverse, is isolated from the parapet in front of it. This magazine is sunk partly in the ground, the sides being formed of planks and the roof of strong scantling, forming a ridge in the centre covered first with fascines and then with a coating of two or three feet of earth. Its dimensions are—length 8 feet, breadth 5, height 6.

Having thus generally sketched, as it were, this section of our subject, it is necessary to determine the least size which can be given to redoubts, so as to ensure a sufficient

Fortification.

interior space for the accommodation of the garrison required for the defence of the parapet, remembering that in works not provided with flanking defences the whole parapet, unless secured in part by some insurmountable *natural* obstacle, must be defended.

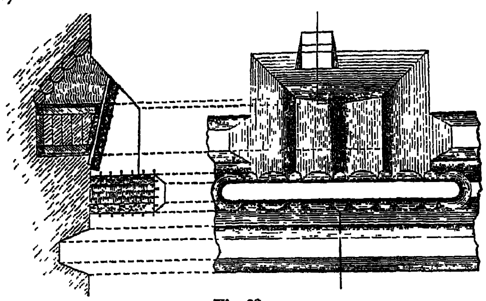

Fig. 32.

A general formula may be easily obtained for determining the least regular polygonal trace in the following manner:—Let x be the side in feet of any regular polygon, n the number of sides, A the interior surface reckoned from the foot of the banquette, y the number of men forming the garrison, f the number of linear feet allotted to each soldier, F the number of square feet occupied by each man in the interior,—then

$$fy = nx, \text{ and } Fy = A, \text{ or } y = \frac{nx}{f} = \frac{A}{F}; \text{ whence } \frac{n\,F\,x}{f} = A.$$

Again, let the perpendicular Cd, from the centre of the polygon (fig. 33) to its side AB, be p; the distance db from the side AB to the boundary line of the available interior space mn be d; then $Cb = p - d$; and as $Cd : AB :: Cb : mn$, $p : x :: p - d : mn$, or $mn = \frac{px - dx}{p} = x - \frac{dx}{p}$. Now, the value

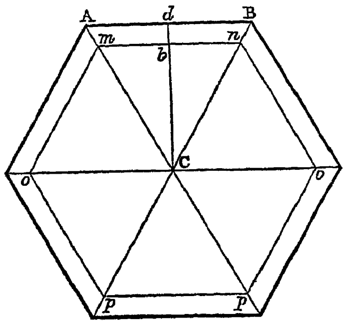

Fig. 33.

of p expressed as a function of x and of the angle of the centre ϕ, which is $= x\ \frac{1}{2}$ cot. $\frac{1}{2}\ \phi$, varies with the nature of the polygon; and replacing, therefore, the variable coefficient $\frac{1}{2}$ cot. $\frac{1}{2}\ \phi$ by β, $p = \beta x$, and mn, the side of the interior space $mnpo$, $= x - \frac{dx}{p} = x - \frac{dx}{\beta x} = x - \frac{d}{\beta}$, and $Cb = mn \times \frac{1}{2} \text{cot.} \frac{1}{2} \phi = \beta \left(x - \frac{d}{\beta}\right)$. The surface of the interior triangle $Cmn = \frac{1}{2}\, mn \times Cb$ is therefore $= \frac{1}{2}\, \beta \left(x - \frac{d}{\beta}\right)^2$, and $A = \frac{n\beta}{2}\left(x - \frac{d}{\beta}\right)^2$; whence $\frac{n\,F\,x}{f} = \frac{n\beta}{2}\left(x - \frac{d}{\beta}\right)^2$, and by reduction $x = \frac{1}{\beta}\left\{d + \frac{F}{f} + \sqrt{\frac{F}{f}\left(2d + \frac{F}{f}\right)}\right\}$. The variable $\beta = \frac{1}{2}$ cot. $\frac{1}{2}\ \phi$ is as follows:—

In the triangle,	0·288
„ square,	0·500
„ pentagon,	0·688
„ hexagon,	0·866

and taking the square under the following conditions:—$d = 12$ feet, $f = 3$, $F = 6 \times 3 = 18$, $x = 62{\cdot}81$ feet (21 yards), which may therefore be taken as the side of the smallest square redoubt to be defended by one rank only of soldiers, the garrison being 84 men with a single rank: and a reserve equal to $\frac{1}{3}$ of the garrison; $f = 2$, and $x = 76{\cdot}66$ feet, or nearly 26 yards, the garrison being 156 men. If there are to be two ranks, $f = \frac{3}{2}$ and $x = 89{\cdot}6 = 30$ yards nearly, the garrison being 240 men; and if two ranks, with a reserve equal to $\frac{1}{3}$ the whole garrison, $f = 1$ and $x = 115$ feet, or about 38 yards, the garrison being 456 men.

Fortification.

Triangular redoubts are rarely used, from their small interior space as compared with the length of their parapet; thus the smallest triangular redoubt intended to be defended by a garrison of two ranks should have a side (x) 54 yards in length, and a garrison of 324, the total length of parapet required to be constructed for this force being 162 yards; whereas a square redoubt of 38 yards' side will accommodate a garrison of 456 men, admitting of a two-rank defence, and of a reserve of $\frac{1}{3}$ the whole garrison, with a total length of parapet of only 152 yards; and this objection of limited space is further strengthened by the great amount of dead-angle space before the salients. Keeping these numbers, as regards square redoubts, in recollection, the engineer will be able at once to determine his arrangement of the proposed garrison, and yet to limit himself to the least amount of work in parapet. If, however, he has to provide for guns, for traverses, or for other constructions, he must increase the side of his square, remembering that in the case of the square of 38 yards' side the augmentation of 1 yard per side will require only the addition of 12 men to the garrison, making it 468, and the additional interior space for their accommodation of 216 square feet; whereas there will be a gain of space of 549 square feet, leaving an excess towards the objects stated of 333 square feet; and if the side were increased to 45 yards, and the garrison to 540 men, there would be a surplus interior space of 2709 square feet, being sufficient for barbettes for three guns and for one howitzer, and for a traverse; and this size may therefore be assumed as the best for a normal redoubt. It is generally stated that, passing this limit, some of the forms of forts should be adopted, as diminishing to a certain degree the defects of redoubts, by introducing more or less perfect flanking defence; but in practice it will be often preferable to use a larger redoubt, as the flanking defence obtained on very short lines must be extremely imperfect, and therefore more liable to deceive by false security than to benefit. In Pl. CCLIX., fig. 5, one of the angles is shown with an indented parapet as a means of correcting the defect of a dead salient; but this is difficult of construction, and it will generally be preferable either to cut it simply off as in another angle of the figure, or to round it as in a third, or to occupy it by a gun *en barbette*, as in the fourth. Of forts, fig. 6 exhibits a star fort of eight points formed upon a square, which is far preferable to one of six points formed upon a triangle, as giving comparatively more available space. The defect, however, in this trace is, that though the intermediate angle F is sufficiently open—as it exceeds 60°,—the angles A and B are less than 60°. Down to the lowest limit of such forts, in which AB of fig. 6 is taken at 60 yards, and the sides AE, EF, EB at 20 yards, there is still sufficient space to accommodate the necessary garrison, which should be in that case about 900 men. It is useless to describe those forms of star forts, which would not accommodate the required garrisons; but that represented in fig. 34 (next page) is well fitted for a large garrison. A simple construction on a pentagon is:—Bisect AB in C; make the perpendicular $CP = \frac{1}{4}$ AB; join AP and BP; make Bd and Ad each $\frac{5}{12}$ of AB, and joins dc, dc. In this case the angles at A and B will be 64°, and the short sides (with an exterior side of 120 yards) each 23 yards. From what has been already said in a preceding page, half-bastion forts,

CCLIX., fig. 12, will rarely be adopted; but when the extent of the proposed garrison is such as to require a large amount of accommodation, and there is time to undertake such works, the bastioned trace should be adopted, as it introduces a principle not observed in the preceding traces, namely, that of defending the whole by a part, the opposite flanks EG, FG of the two bastions GEAFG, GFBFG, defending the intervening curtain GG between them, as well as the faces AE, BF of the bastions—whilst the fire of one flank necessarily sees the scarp of the opposite one and defends it. The bastions are indeed, like their analogous lunettes, works in themselves; the curtain being only a connecting line, forming several bastions into one connected whole. Pl. CCLIX., fig. 7, is a square bastioned fort, but the pentagon is a better form, and should be adopted when practicable. It may be said that the bastioned form of field forts has been derived from the more massive structures adopted in the permanent defences of fortresses, whilst the other traces have naturally sprung out of the earliest and rudest works even of savage tribes, for they too had their redoubts, and have only been reduced to more definite rules by the progress of military science. The history, therefore, of the bastion trace, so interesting in itself, will be postponed to a future page. Little more then requires to be said on this section of the subject, further than to point out the great importance of field-works, in securing a base of operations for an advancing army. Pl. CCLIX., fig. 13, exhibits, for example, a bridge head consisting of a bastioned front, with either simple straight branches or branches provided with a short flank as shown in the figure (see also fig. 35 below). This is, as stated before, technically called a horn work; and if there had been two such fronts so placed as to throw a bastion in the centre, and connected as before with the river by straight branches, the work would have been called a crown work. Lunettes also may be used, and evan redans constructed, as fig. 1 of the plate (left side), for a similar purpose, where the object is simply first to secure the bridge from

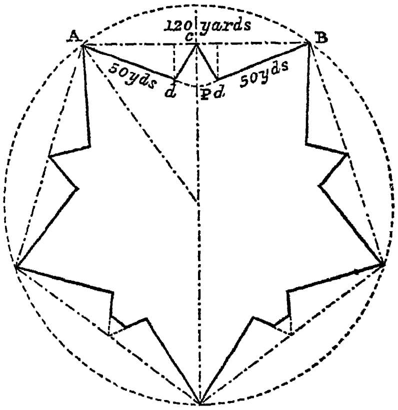

Fig. 34.

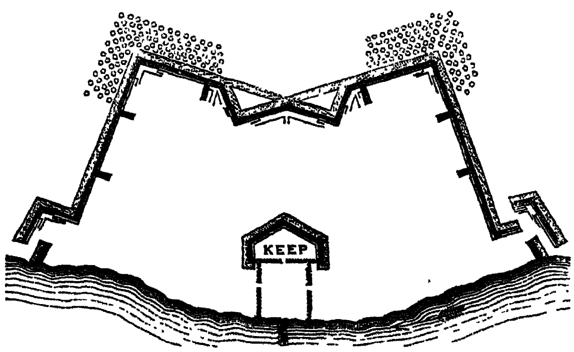

Fig. 35.

the enemy's attack and fire, and secondly to allow the defending army to manœuvre on the opposite side when desirable: but just in proportion to the numbers passed over the bridge, and to the extent of advance contemplated, will it be necessary to increase the importance of the works forming the bridge head, as it will be often necessary to form more than one bridge in connection with it. Nothing can be more fatal to a retreating army than to find itself driven back to a river, and to have no sufficient line of intrenchment to enable it to maintain its ground whilst its arrangements for passing the river are in progress. Fig. 35 exhibits one such arrangement in which the horn work front has been much enlarged, and a lunette as a keep introduced within it. The mode in which the troops can move out at the sides, under protection of covering and flanking parapets, is shown, as well as the barbettes for guns, which become necessary in works having so important an object. Fig. 36 represents a line of tenaille intrenchments in front

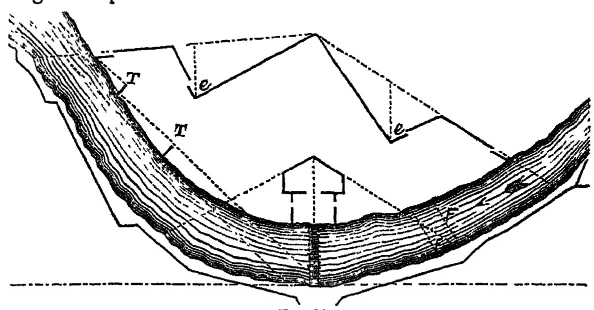

Fig. 36.

of the lunette, and a line of intrenchment is also shown on the near side of the river, from part of which the last terminal branches of the tenailles are flanked. In this figure T, T represent traverses, and F, F either chains or lines of pickets placed across the stream; the object of the first being to secure the bridge from the ricochet fire of the enemy, and of the second to secure it from destruction by burning or explosive bodies launched by the enemy in the stream, and allowed to float down. More extended intrenchments might be formed of lines of lunettes with intervening intrenchments; but it is unnecessary to pursue the subject in this suggestive manner further, as the engineer must necessarily adapt his works to the nature of the ground, and to the extent of the army for which he is required to prepare in this manner a defensive position, from which it may either advance or retire, without risk or confusion, as the necessities of war may require.

RAMPART OR TOWN FORTIFICATION.

Rampart fortification.

If, as has been stated, the simple lines or works of parapet fortification appear to have been adopted even by the rudest tribes of wandering savages, for their temporary defence or security, the more massive and artistic works of rampart defence would seem to imply a certain amount of civilization. As an art, indeed, fortification is very nearly as ancient as the existence of society. When men first assembled together for the purpose of mutual protection, and placed their habitations on the same spot, the law of necessity, springing in this case out of the principle of self-defence, rendered it indispensable for them to adopt some means for securing their families and their property against the sudden inroads of enemies. Hence, when Cain, the son of Adam, built a city, he surrounded it with a wall; and, in like manner, the Babylonians, when they built cities soon after the Deluge, encompassed them with similar defences. In the early ages, men considered themselves as sufficiently protected by a single wall, from behind which they could with safety discharge their darts, arrows, and other missiles, against an assailant. But when, in the progress of improvement, new and more powerful means of attack were discovered, it became necessary to increase, in a corresponding degree, the inert force of resistance; and

accordingly the feeble defensive structures of the primitive ages were in time succeeded by solid ramparts, flanked and commanded by elevated towers. In short, as the power of attacking fortresses or places of strength was augmented by successive devices and inventions, the means of resistance were proportionally increased, until the art of fortification arrived at a state of comparative perfection, in which it remained for many ages nearly stationary

The various improvements which were from time to time made in strengthening the walls, and adding to the defences of ancient cities, are recorded in history, and need not be detailed in this place. The first walls which we read of consisted of brick, the material employed by Cain for the protection of the city which he founded, and called by the name of his son Enoch. Amongst the ancient Greeks, brick and rubble stones intermixed were used for the same purpose, as we find from the description of the wall which connected Mount Hymettus with the city of Athens; but, in addition to such structures, should be noticed the works, surrounding several cities, of Cyclopean structure, built of huge stones, placed with their longer axis transversely to the line of wall, and arranged with great care and skill, though without mortar. The walls of Babylon and Nineveh indicate a prodigious advancement in the art of fortification, and are justly accounted amongst the wonders of the ancient world. Those of the former city, ascribed by some to Belus, and by others to Semiramis, were thirty-two feet in thickness, and one hundred feet in height, surmounted by towers at an average ten feet higher, and cemented by means of bitumen or asphaltum; they encompassed a vast area, and presented a solid defence, which no means of attack known in ancient times were sufficient to overcome or beat down. The walls of Jerusalem, though of smaller dimensions, appear to have been little inferior in strength and solidity to those of Babylon; for, in the siege of that capital by Vespasian, all the Roman battering-rams and other engines, though used with the utmost vigour, required a whole night to disengage four stones in the masonry of the tower of Antonia. But when fortification had arrived at the state in which we find it in the works of these and other cities, it remained stationary for ages, and perhaps even retrograded somewhat, until the discovery of gunpowder, the invention of artillery, and the application of both to military purposes, effected an entire revolution in the principles of attack and defence. Then the round and square towers, which had formed secure flanking defences against assailants armed only with arrows and with darts, afforded no protection against the projectiles discharged by cannon; and even those battlements which had defied the catapult and the battering-ram speedily yielded to the force with which they were now assailed, whilst their defenders were at the same time destroyed, or buried in their ruins.

It being thus found that the ancient system of fortification was of little or no avail against the new method of attack which had been discovered, and which came into general use towards the close of the fifteenth century, it became indispensably necessary to adopt another method of defence. The plan of fortifying with bastions is believed to have commenced with the Italians early in the fifteenth century; though Papacino D'Antoni, professor of artillery and engineering of Turin, states, in his *Architettura Militare* (1759), that several small bastions had been constructed in the preceding century, and that the ruin of a large bastion which had formed part of the fortifications of Turin, built for Duke Louis of Savoy, still existed in the royal gardens at that time. The bastions on the enceinte of Verona, built by the Italian engineer Micheli, in the year 1523, are generally supposed to be the oldest extant; and the next, probably, are those still to be seen in the citadel of Antwerp, and which were constructed for the Emperor Charles V. in the year 1545, by the Italian engineer Paciotto D'Urbino. These bastions are small, with narrow gorges and snort flanks and faces; and they are placed at a great distance from one another, it being the invariable practice, at the time when they were built, and for a considerable time afterwards, to attack the curtains, and not the faces, of the bastions.

Errard of Bois-le-duc, one of the principal officers of the engineer corps first organized by Sully, prime minister of Henri IV., and from which has sprung the French Corps du Genie, was the first in France who laid down rules respecting the best method of fortifying a place, so as to cover its flank. At the command of the minister, he wrote a book on the subject, which was published in 1594, and in which the details of his method are explained. As a writer on fortification, he was preceded in France by Beril de la Treille, who published his work on fortifying towns and castles in 1557. Errard fortified inwards; and in the square, pentagon, hexagon, heptagon, and octagon, he made the flank purpendicular to the face of the bastion; but in the enneagon, and in all polygons of a greater number of sides, he made it perpendicular to the curtain. In endeavouring to accomplish his object, however, he made the gorges too small, the embrasures too oblique, and left the ditch almost defenceless. This engineer constructed part of the enceinte of the citadel of Doutens, as well as the citadel of Amiens, and also some works at Montreuil and Calais.

The Chevalier Antoine de Ville, who succeeded Errard, published a treatise, dated 1629, in which he completed much that his predecessor had only sketched, and rectified various defects in the method of the latter. The Chevalier was employed under Louis XIII., and constructed new enceintes for Montreuil and Calais. His plan of fortifying has been denominated by some the French method, and by others the Compound System (*Système à trait composé*), because it united the Italian and Spanish methods, from the latter of which it differs only in having no second flanks and fichant lines of defence, and in not confining the flanked or salient angle of the bastion to ninety degrees. The leading maxims of the Chevalier de Ville were, to place the flanks perpendicularly to the curtain, to make them equal to the demigorges, or each equal to a sixth part of the side of the interior polygon, and, in the hexagon and all higher polygons, to confine the flanked angle to ninety degrees. But this plan is liable to nearly the same objections as that of Errard; for here, also, the embrasures are too oblique, especially in the polygons, and the ditch is necessarily but ill defended.

Sixteen years after the publication of De Ville's treatise appeared the work of the Comte de Pagan, which issued from the press in 1645, and contained the development of a system which, in a short time, entirely superseded those of his predecessors. In fact, it was the Comte de Pagan who first disengaged the science of fortification from a number of suppositions which custom had in some measure consecrated, and which, resting more on abstract mathematical reasoning than on practical observation and experience, had hitherto retarded the progress of the art. This engineer acquired great reputation during several sieges which he assisted in conducting under Louis XIII.; but having become blind at the age of thirty-eight, he was obliged to retire from the service, in which he had already obtained the rank of mareschal-de-camp, and he died six years after completing the treatise above-mentioned, in which he embodied a full exposition of his system. The Comte de Pagan made the flank perpendicular to the line of defence, in order as much as possible to cover the face of the opposite bastion; and he also pointed out a method of building casemates in a manner peculiar to himself. Vauban borrowed from the Comte de Pagan the length of his perpendicular, and Allain Manesson Mallet, whose construction

still remains in favour with many, also proceeded upon the principles laid down by this scientific soldier.[1]

The Mareschal de Vauban was born in 1633; and in 1655, at the time of the Comte de Pagan's death, he had already acquired reputation at several sieges. Vauban followed up the principles suggested by Pagan, and employed them extensively in practice, with consummate skill and judgment. He constructed thirty-three new fortresses, repaired and improved one hundred; and having conducted about fifty sieges, he left his extensive works, and a treatise *De l'Attaque et de la Defense des Places*, published in 1737, to speak for themselves. From the different constructions observable in these works have been compiled the systems which, in the military schools, are denominated Vauban's first, second, and third systems of fortification, and which the reader will find developed in the sequel. Had the genius of Vauban been applied to the discovery of a method for securing a permanent superiority to the defence of fortified places, posterity would have been greatly indebted to him, and even humanity would have had cause to rejoice in such a triumph of military art. But, being engaged in the service of the most ambitious monarch of modern times, Louis XIV., he applied his great talents to forward his master's views, and soon perfected that irresistible system of attack,[2] which has ever since been so successfully followed. Before his time the general superiority was on the side of the defence; but ever since, the case has been so completely reversed, that the success of an attack made with adequate means, and scientifically conducted, is a matter of ultimate certainty.

Nor should the protracted siege of Sebastopol be considered an exception to this rule, as the principal cause of its hitherto successful defence must be sought in its freedom from investment and the consequent incessant renewal of its garrison, thus withdrawing the siege operations from the influence of the sound maxims of Vauban.

Considering that at this time, when the public mind is generally impressed with a desire to have a more practical bearing given to general education, there still may be a tendency on the part of public authorities to retrograde as regards military education, and to *substitute* for the mathematical sciences the classical languages, it is well to notice briefly the characters of Errard, of Pagan, and of Vauban. Errard was one of the most distinguished members of a corps formed out of the best instructed and most experienced military men he could find, by the great Sully, who was grand-master or master-general of the artillery in the reign of Henri IV. of France. This corps, called by Sully "Engineers in ordinary to the King," has now become the Corps du Genie, and has to this day maintained its high character as a body of scientific men. Compte Pagan had from his earliest years devoted himself to the study of mathematics and fortification. At the age of thirty-eight he was afflicted by blindness, but before that time he had served with distinction at twenty-five sieges, and acquired the rank (then second only to that of marshal of France) of field marshal. Besides his celebrated work on fortification, he published several others on Astronomy. Vauban was no ordinary man in any sense. As the inventor of parallels in sieges, and of the ricochet fire, he stands on the first rank of military engineers for invention, and when it is considered that he conducted fifty-three sieges and shared in 140 battles and skirmishes, he must be considered an equally experienced one. At fifty-five years of age he attained the highest honour of the French army, being created marshal of France; yet amidst this stirring and successful military life he never failed to turn to account the geometrical knowledge for which he was distinguished when a youth, and which had obtained for him the early notice of the Prince de Condé. His mind was, therefore, never idle, but constantly directed to projects of public utility, whether military or civil, and he left behind him records of such labours in twelve folio manuscript volumes, entitled *Mes Oisivetés*, at once a monument of his own ability and industry, and a beacon to guide subsequent engineers to that course of useful as well as intellectual activity which it ought to be their pride to follow.

M. Minno Baron de Coehorn, first a general of artillery, then a lieutenant-general of infantry, and ultimately director-general of all the fortified places belonging to the United Provinces of Holland, was the contemporary and rival of Vauban. This able engineer, convinced that, however expensively the rampart of a town may be constructed, it cannot long resist the shock of heavy ordnance, invented three different systems for throwing such obstacles in the way of a besieging force, that, although the place be not thereby rendered impregnable, it can only be approached with great difficulty and hazard. But these methods, without much modification, are only applicable to low and swampy situations, such as are to be found in Holland, and are therefore not available where the localities are of a different or opposite description. At the same time, Bergen-op-Zoom, Manheim, and other places fortified by this engineer, particularly the two former, have very great merit, inasmuch as it is impossible for a besieger to penetrate into any of the works, without being exposed, on all sides, to the fire of the besieged, who are under cover; and from artillery and musketry it is scarcely possible for an assailant to shelter himself. In fact, Coehorn was a great master, and combined, as will be observed hereafter, many of the means of defence springing from another source with the bastioned trace. He published his first work on fortification before he had acquired much practical experience; and in fortifying Bergen-op-Zoom, which is allowed to be his masterpiece, did not reproduce, except as fragments, any of his published systems.

Since Vauban's time several improvements have been suggested, particularly by Cormontaigne, who entered the corps of French engineers in 1716, nine years after Vauban's death, and died a mareschal-de-camp in 1750. Some account of the system of Cormontaigne will be found in a subsequent part of this article. The three methods delivered by Belidor are all applicable to an octagon of two hundred toises. Scheiter distinguished his systems into great, mean, and little, in imitation of Pagan, requiring the exterior sides of the polygon to be, respectively, two hundred, a hundred and eighty, and a hundred and sixty toises: he adopted from Castriotto detached bastions, and made use of a continuous fausse-braye. Fritach, a Pole, proposed two methods, which he exemplified on different polygons. Dogen, a Dutchman, published a large volume on fortification, in which, after enumerating various modes employed by different writers for determining the salient angle, he selected three as the most approved, and proposed as many methods of construction, one of which is borrowed from Fritach, the Pole. Pietro Sardi, an Italian, suggested a peculiar method of construction on a hexagon. The Sieur de Fontaine found the flanked or salient angle of the bastion by adding fifteen degrees to half the angle of the figure, from the square up to the dodecagon, in which last it becomes ninety degrees, and at this he continued it in all the higher polygons. He also constructed outwards, and, in every regular figure, made the curtain equal to seventy-two

[1] Mallet constructs outwards, making in every figure or polygon the demigorge equal to a fifth part of the side of the interior polygon or figure, the capital of the bastion equal to a third part of the same side, the curtain equal to three-fifths or thrice the demigorge, and the angle of the flank equal to 98°. The faces of the bastions and the flanks are determined by the lines of defence, which are razant. From these data all the other lines and angles are easily found.

[2] See his work *De l'Attaque et de la Defense des Places*, passim.

toises, the face of the bastion to forty-eight, and the flank, which he placed perpendicularly to the curtain, to eighteen toises, or a fourth part of the curtain. Ozanam and Muller delivered each four methods of construction, the particulars of which will be found in their respective works. In 1751, Charles Bisset, who, as an engineer-extraordinary, served with the Duke of Cumberland in the Netherlands, and was present during the siege of Bergen-op-Zoom by the Mareschal Lowendahl, published a treatise on the theory and construction of fortification, in which there are many sensible and judicious remarks; and the same general description may be applied to an *Essai sur la Fortification, ou Examen des Causes de la grand supériorité de l'Attaque sur la Defense*, published anonymously in 1755. In a work entitled *Science de la Guerre*, which appeared at Turin eight years before the date last mentioned, a new method of construction is proposed, in which the principal objects to be attended to are, that there be mines under all the works, and that a regular communication be kept up with the chambers by means of subterraneous galleries, to be resorted to in proportion as the enemy approaches the body of the place. The third volume of the *Œuvres Militaires* contains some useful observations and maxims relative to irregular fortification; and in the Supplement to the *Rêveries* of Mareschal Saxe, by Baron d'Espagnac, the subject of fortification generally is amply discussed, and an accurate description given of the different means of attack and defence. Besides the writers above enumerated, may be mentioned the Chevalier St Julien, an able engineer, who published a method by which, he asserts, works may be constructed at a less expense, yet in such a manner as to render the defence or attack more formidable; Francisco Marchi, of Bologna, who, in 1599, furnished no less than a hundred and thirty-nine different methods of constructing fortifications, many of which are very valuable, and afforded useful hints to subsequent engineers, who have indeed greatly profited from his work; Bombelle, who established three kinds of fortification, called the grand royal (*grand royal*), the mean royal (*moyen royal*), and the little royal (*petit royal*); Blondel, who published a system divided into two principal heads, the great and the little, whose exterior sides are respectively two hundred and a hundred and seventy toises; Donato Rosetti, a canon of Livorno, who wrote on the method of constructing works in what he calls *fortification à rebours*, or fortification in reverse, so denominated because the re-entering angle of the counterscarp being opposite to the flanked angle, it will, according to him, be necessary to attack it from the reverse side of the other works; and Antonio de Herbart, major of artillery in the Duke of Wurtemburg's service, who published a treatise on fortifications with what he calls *angular polygons*. The treatise entitled *Nouvelle Manière de fortifier les Places, tirée des méthodes du Chevalier de Ville, du Comte de Pagan, et de M. Vauban, avec des Remarques sur l'ordre renforcé, sur les desseins du Capitaine Marchi, et sur ceux de M. Blondel*, which appeared in 1689, is full of strong reasoning, whence the author deduced a new system; but it contains little that is really original, though it gives numerous references to what had previously appeared, and disposes the different parts in a judicious manner. M. de Montalembert's system of casemated and reverse fire has been in part adopted in the splendid fortress of Alessandria in Italy, constructed under the directions of Napoleon.

Of the more recent treatises on fortification, by far the most elaborate and complete is that of M. de Bousmard, entitled *Essai Général de Fortification, d'Attaque et de Défense des Places, dans lequel ces deux Sciences sont expliquées et mises l'une par l'autre à la portée de tout le monde*; a work which enjoys a deservedly high reputation. It is remarkable for great accuracy and research, and may be considered as embodying in itself every thing that is valuable in connection with the subject of which it treats. M. de Bousmard's work, therefore, though intended to serve as an elementary treatise on fortification, is too expensive for the pecuniary means of a great number of inferior officers, whose instruction the author professes to have had chiefly in view: but to teachers of fortification it is altogether indispensable; and as long as the science and practice shall continue on their present footing, it will be deservedly considered as the most comprehensive and valuable work on the attack and defence, as well as the construction, of all kinds of fortification.

With regard to Carnot's *Traité de la Défense des Places Fortes*, it was written to serve a temporary purpose; and the exaggerated celebrity which it acquired on its first appearance has been succeeded by an equally unfounded neglect. The more prominent innovations recommended in this treatise were, first, an alteration, which, however, was not original, in the trace or outline of the polygon; secondly, the suppression of the exterior revêtement of the covered-way, known as the counterscarp; thirdly, the detachment of the scarp-wall from the rampart, and the construction of the latter without revêtement; fourthly, destructive personal conflict with the besiegers by means of frequent sorties; and, lastly, making vertical fire the basis rather than an accessory of the defence. With regard to the first of these proposals, all of which the reader will find very ably discussed in Jones's *Journals of Sieges in Spain and Portugal*,[1] we have only to remark, that by means of an increased expenditure for retrenchments and casemates, as recommended by Carnot, the strength of particular portions of the polygon may be increased; and that, if he has failed in tracing a perfect front, founded on the basis of Montalembert's system of casemated and reverse fire, he has at least rescued a valuable suggestion from unmerited neglect, and rendered an important service to science by directing the attention of military men to the means most likely to create a barrier against the growing powers of the attack.

The *Traité de Fortification Souterraine, suivi de quatre Mémoires sur les Mines*, by M. Mouzé, lieutenant colonel of engineers in the French service, was published at Paris in 1804, and is justly considered as the most complete work on the subject it treats of which has yet been given to the public. Subterranean fortification is a branch of the art which, until a very recent period, was wholly neglected in this country, and in which our engineers were far behind their brethren of the continent. We learn from Colonel Jones's work on the Peninsular Sieges, that the Duke of Wellington's army in Spain was unattended by a single regularly-trained sapper or miner until late in the year 1813; and many valuable lives were sacrificed, from the want of these valuable, or rather indispensable auxiliaries. In this respect things are now changed, and the engineer has the assistance of a body of men well instructed in the duties of the trench, the sap, and the mine; but it cannot yet be said that the corps of sappers and miners has been sufficiently augmented, whilst it may be feared that the growing idea that the ordinary navvies might with advantage replace them, may check the desire of increasing the body. In war, it must be remembered that discipline is as important as skill, and that the labourer who would have worked with the greatest effort under ordinary circumstances might be found very ineffective when forced to work on his knees in a sap, and when exposed to an enemy's fire obliged to remove calmly the man before him when killed, and then, with equal composure, to step into his place.

The preceding hasty and imperfect summary of the pro-

[1] Vol. ii., p. 131, *et seqq.*

gress and literature of fortification has been given principally in connection with the bastioned trace, as the one more generally used both in the French and English schools in teaching the principles of the science; and justly so, as, theoretically speaking, it exhibits the most perfect arrangement of flanking or reciprocal defence. It is, however, desirable, before going further, to recur back to the earlier epochs, and to investigate the manner in which the ancient arrangement of a wall, with its round or square towers, passed into the present systems of defence. The accompanying figure (No. 37), will explain the natural and pro-

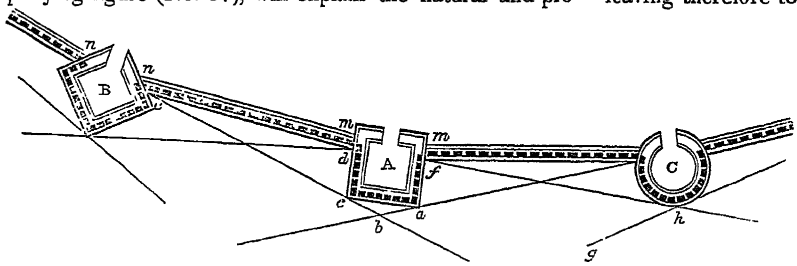

Fig. 37.

bable manner in which the old tower or rather tower-fort (*baluardo*) was changed into a pentagonal bastion. If, for example, lines of defence be drawn from the extremes of two adjacent curtains to the angles *a* and *c* of the square tower-fort A, a space would be left, *c a b*, unseen from the adjacent forts B and C, and therefore undefended, except by downward or vertical fire from machicoulis, or projections from the walls supported by corbels made for that express purpose. Such a space would be turned to account by the besiegers in fixing their scaling ladders; and the change of the straight line *ac* into the two faces *cb*, *ab* seems but the result of a self-evident necessity. As the work became enlarged, the portions of the fort within the connecting walls *m m* were omitted, and the flanks *dc*, *fa* alone remained of the old work, forming with the faces the bastion *fabcd*, which only required to be improved in proportions to become the bastion of modern times. It is, however, said that the towers were sometimes placed with an angle salient as in B, and if so, omitting the portions *n n*, the resulting bastion has a strong analogy to those of Errard before mentioned. By using the old wall merely as a retaining wall, and as an obstacle against escalade, and adding to it a rampart and a parapet of earth, the Italians completed the system of bastioned defence, which, notwithstanding all the modifications of the French, ought to be called the Italian system. In this system, whilst imitating the construction of the old towers by using casemated or masonry-vaulted chambers for artillery, in addition to the guns mounted on the rampart, the Italians placed the musketeers on the banquette of the parapet, and made them fire over it. Now this arrangement of the musketry fire is an essential characteristic of the Italian system, and the reliefs of the several works are hence restricted within certain limits, as it is necessary so to determine the levels of the opposite flanks that the fire along their superior slopes shall defend the whole of the intervening curtain: but there are other modes of using musketry as well as artillery fire in the defence of the ditches, and on these were founded other systems of fortification.

The first *Italian writer* on fortification was Tartaglia, whose work was published in 1546; but the really *first* writer on the science was Albrecht Dürer, at once a great painter, a sculptor, an engraver, and a civil and military architect, whose work is dated 1527, being published one year before his death. This remarkable man founded his system on the old circular tower-forts C, fig. 37, in which the dead space is much less than in the square, and enlarging them to an enormous extent, he adopted the word, "Bastei," or in the plural "Basteien," for his new work. As the attention of military men was at this early period more directed to cannon than to the rude musket as an instrument of defence, it was natural that the latter should be less considered in these arrangements than the former. Dürer based his systems on the principle that the defences of basteien or other works which depend only on the cannon placed on their terreplein, may be effective whilst the enemy is at a distance, but cannot be so when the enemy, under cover of his epaulements, has advanced to the ditch; and leaving therefore to the cannon on the terreplein the task of firing upon the enemy's troops and batteries at a distance, he placed his cannon, and it may be said also his musketry, either in vaulted galleries running along the base of the scarp, or in caponnieres, also vaulted or casemated works, built across or transverse to the ditch. The great circular bastei of his third and most improved system was no less than 130 yards in diameter, with a scarp 120 feet high, a ditch in front 100 feet wide, and a massive envelope, about 80 feet thick and 100 feet high, formed of earth with thick masonry revêtements both in front and in rear, as a mask between the main work and the counterscarp. Such gigantic proportions as these have led many to consider Dürer as little more than a speculative writer, but this would be an unjust estimate of his real merits. Reducing his works to more reasonable dimensions, they would, with proper modifications, have become practicable, and have afforded many useful hints to the scientific engineer. The defects of the circular form were compensated by the grazing fire of the caponnieres in his system, and the main work was retained in an effective state by the cover afforded to it by the envelope. We shall have occasion to refer again to Dürer, but in the meantime it may be said that whilst the Italians are properly considered the originators of bastioned systems with an earthen parapet over which the musketry fire is directed, Dürer has an undoubted claim to be considered the author of the other branch of fortification in which casemated defence in the main works, as also in caponnieres, becomes the essential characteristic—a branch which has proved as fertile in results in modern times as the bastioned system.

SYSTEMS OF PERMANENT FORTIFICATION.

1. *Vauban's First System.*

Before commencing to draw a plan of fortification, it is usual to determine upon some polygon on which to describe it. In this figure, accordingly (see Plate CCLX. fig. 1), we have taken the angle of an octagon, and called the length of the side 360 yards. In constructing a fortification, a figure is determined on, as near that of a regular polygon as possible, within which the enceinte or chain of main works is to be contained. The enceinte or body of the place consists of as many bastions, connected with curtains, as there are sides to the figure, and each of these is made as near 360 yards as possible, so that every part may be within range of such arms as are to be employed in its defence.

The *principal* or *outline* denotes the contour or line by which the first figure of the work is defined. This line is supposed to pass along the superior part of the cordon, and is that from which all the other parts of the work are set off.

The *exterior side*, or side of the polygon above mentioned as equal to 360 yards, is that upon which the front of the fortification is described, and it extends from the flanked angle of one bastion to the corresponding angle of the next, as AB. These lines are bisected, and a perpendicular, DC

is drawn from the point of bisection towards the place, its length being proportional to the extent of the exterior side and adjacent angle of the polygon; that is, one-sixth for the hexagon and all figures of a greater number of sides, one-seventh for the pentagon, and one-eighth for the square.

The *lines of defence* AEG, BEH, are drawn from the extremities of the exterior sides through these points, and produced to an indefinite length; and upon the lines so drawn are set off two-sevenths of the exterior sides, equal to 102$\frac{6}{7}$ yards, which marks out the point for the shoulder of the bastion E and F. The distance between these points is then laid along the continuation of each line of defence, and a line is drawn connecting them the curtain GH, from the extremities of which lines are drawn to the point marked off for the shoulder of the bastion, and thus form the flanks. And in this manner is drawn a front of fortification, which being repeated round the sides of the polygon, completes the works of the enceinte or body of the place.

Vauban divided his first system into three parts; namely, the little, the mean or intermediate, and the great. The first he used for small forts of four or five sides, citadels, horn-works, and crown-works, making the exterior sides from 120 to 240 yards, the perpendicular in the square equal to one-eighth, and in the pentagon one-seventh, and the faces of the bastions in each equal to two-sevenths of the exterior side. In the mean or intermediate, which is adapted for all sizes of towns, the exterior side varies from 250 to 360 yards, the perpendicular is one-sixth, and the faces are two-sevenths. In the great the exterior side varies from 360 to 520 yards. This kind was never adopted for *all* the sides of a place, but only when *one* of these happened to be near a river or a marsh; in which case the distances of the bastions should be so regulated that they may not be out of musketry range from one another. When the curtain becomes unavoidably too long, this defect is in part remedied by erecting on it a flat bastion, which is not so high as the rest of the works.

Ground which will admit of being regularly fortified throughout is seldom or never to be met with, but, nevertheless, the rules of regular fortification must be observed as nearly as possible; that is, the flanked angles should not be less than 60°, the lines of defence should not exceed musket range, and the sides should be lengthened or shortened so as to obtain a well-proportioned front upon each. After an irregular place has been reduced to as regular a form as possible, lines are drawn parallel at the distance of about 30 yards from the houses, in order to give sufficient space for the rampart; and these lines form the interior polygon, which may be fortified inwards, by setting off the demigorges of the bastions, and raising their flanks at an angle of 100° with the curtain: Or, the exterior side may be formed and fortified inwards by drawing a line parallel to each of the interior sides; and when the angle is that of a polygon of more than five sides, the distance from the exterior to the interior sides should not be less than 100 yards. If a side extend from 360 to 520 yards, the perpendicular should be diminished to about 50 yards, and the faces of the bastions be made from 100 to 120 yards. When a side is very long, it may be divided into several parts of from 340 to 360 yards each, which may be fortified with flat bastions, as was occasionally done by the Italians, an example of which may be seen in the bastion Anastasius at Corfu. All these dimensions may, however, be now much increased, and placed more in relation to the range of the modern musket.

The *ditch* or *fosse* is an excavation of from 12 to 24 feet in depth, and from 30 to 50 yards in breadth, surrounding the rampart on the exterior side, and the earth dug out of which serves to raise the rampart and parapet. The side of the ditch next the place forms part of the *escarpe*, the side next the country is called the *counterscarp*, and it is made circular opposite the salient angles of the works. In fig. 1 arcs are described with a radius of 30 yards, opposite the salient angles of the bastions, tangents to which are drawn upon the shoulders of the neighbouring bastions, and thus form the ditch. The general dimensions of a ditch should be such that its excavation, or deblai, would produce sufficient earth, or remblai, for the formation of the works. The breadth varies from 30 to 50 yards, in order that, in passing across it to the assault, the enemy may, for a considerable time, be exposed to the fire of the works; and its depth must also be such as to render difficult the escalade of the parapet, as well as to prevent the besiegers at the crest of the glacis from being able to see to breach the lower part of the revêtement of the escarpe. The line of the counterscarp is drawn from the rounding at the salient angles of the bastions upon the shoulders of the bastions next adjoining, in order that the whole of the ditch may be defended by the fire of the flanks of the collateral bastions. Ditches are of three kinds; wet, dry, and such as may occasionally be rendered either wet or dry. The wet ditch is calculated to prevent sudden surprises or assaults, excepting during hard frost, as in the attempt made to surprise Bergen-op-Zoom in the year 1814; but, independently of this exception, the number of bridges of communication, which require continual repair, and the difficulty of making sorties, which a wet ditch creates, renders it extremely inconvenient. A dry ditch, which is capable of containing works for its own defence, and by means of which communications round the works may more easily be maintained, is therefore preferable to a wet one; but the third kind, which unites the advantages of the other two, should, when practicable, be preferred to either. It is only in particular situations, however, that the advantage of such a ditch can be obtained.

The *tenaille*, in the form given to it by Vauban, does not appear in the works of earlier engineers, but it seems to be naturally derived from the trace of Rimpler (1673), in which the *middle flank* is analogous in function to the tenaille, and occupies its position; it is a work placed in front of the curtain, and is formed by the continuation of the lines of defence, at the distance of ten yards from the angle of the shoulder; the ends are then drawn parallel to the flanks of the bastions; it is made sixteen feet broad; the angle formed by the meeting of the two lines which determine its rear is then cut off, at the distance of ten yards, parallel to the curtain; and another line is drawn at the distance of sixteen yards, parallel to this, and forming a small curtain upon the line of defence or front of the tenaille. The relief or height of the tenaille is determined by that of the neighbouring flanks, and it has a parapet of seven or seven and a half feet in height, and from twelve to fifteen feet in thickness. The use of the tenaille is to cover the postern gate, which is often made in the curtain or flank, when the ditch is dry, to protect the troops who may be formed behind the work for the defence of the ditch; and when the ditch is a wet one, to cover the boats which may be collected for the same purpose. It also serves to augment the defence, as its fire, from being more horizontal, and nearer to the plane of the bottom of the ditch than that from the flanks, is of course proportionally more effectual.

The *ravelin* or *demilune* was a work originally designed to cover the entrance gate and ridge of a fortress, but it soon assumed the dimensions and performed the office of a most important work of defence, appearing as such in some early Italian traces. Speckle, the great German engineer, who fortified Schlottstadz, Hagenau, Ulm, Colmar, Bâle, and Strasbourg, was, however, the first who recognized fully its importance, and laid down as a rule that "great ravelins materially augment the defensive power of

a bastioned system." Acting upon this principle, the ravelins of Speckle were even larger than are those of Cormontaigne's system, and covered nearly the whole of the faces of the bastions, the faces of the ravelin being directed on the salients of the bastions and their capitals, extending about 150 yards in advance of the exterior side of the polygon. Speckle was another man of science, having studied mathematics and military engineering in his youth, and then perfected his knowledge by personally visiting and studying the most remarkable Italian fortifications existing in his time. The Ravelin is a work constructed opposite the curtain, and composed of two faces meeting in an outward or salient angle, with two demigorges formed by the counterscarp. Its use is to cover the curtain, the gates, and the flanks of the bastion. The ravelin is constructed as follows: eleven yards are set off along the faces of the bastion from the shoulder; an arc is described from the angle of the flank upon the perpendicular produced, with a radius of 160 yards; from this intersection lines are drawn bearing upon the points set off at eleven yards from the shoulders of the bastion, but not further than the lines of the counterscarp; and at the intersection of the lines of the counterscarp or re-entering angle six yards are set off on the capital or line bisecting its angle, whence lines are drawn parallel to the lines of defence till they meet those of the counterscarp. Stairs, called *pas-de-souris,* are constructed here in order to facilitate the entrance of the ravelin from the ditch. The ditch in the ravelin, which is twenty-four yards in breadth, is made circular at the salient angle, and drawn parallel to the faces till it joins the main ditch.

The *covered-way* was first described by Tartaglia in 1554, so that it must have been used at a very early epoch of Italian fortification. Some of the first bastioned fortresses were, however, without this highly important work; and it is recorded that at the siege of Vienna by the Turks, the garrison having made a sortie, some companies were pursued by the Turks up to the counterscarp, and forced over it into the ditch. The necessity of being able to assemble the troops intended for a sortie *under cover* from the enemy's fire, and to afford them when repulsed a place for reforming and checking the enemy's progress, and thus insuring an orderly retreat into the body of the place, soon became apparent, and a covered-way was supplied to works originally constructed without one. It is a space of ten yards in breadth, extending all round the counterscarp of the ditch, and covered by a parapet of from seven to nine feet in height, with a banquette. The superior part of this parapet forms a gentle slope towards the country, which terminates at the distance of from forty to seventy yards; and this slope is called the *glacis.* The covered-way serves for drawing up troops in order to make sorties, and costs less than any other part of the works in proportion to the difficulty of taking it. In the salient and re-entering angles of the covered-way spaces are contrived which have been denominated *places of arms.*

The *salient places of arms* are formed by the circular parts of the counterscarp, and the prolongation of the branches of the covered-way till they intersect. The *re-entering places of arms* are constructed with two faces, forming a salient angle of 100° with the covered-way. The demigorges of the re-entering places of arms are generally from twenty-four to thirty yards; but when they are intended to contain a redoubt or intrenchment, they are from forty to forty-eight yards. The re-entering places of arms are meant to flank the branches of the covered-way, and to contain the troops for its defence. The salient places of arms also serve for assembling the troops destined to defend the covered-way.

Traverses are constructed across the covered-way, upon the prolongation of the sides of the ravelins and bastions, perpendicular to the line of the counterscarp; they are from eighteen to twenty feet thick, and serve to cover the troops from the enfilading fire of the enemy. Other traverses should be constructed between these, so that the distance from the one to the other should not exceed thirty-six or forty yards. Openings are cut into the parapet of the covered-way about ten or twelve feet wide, in order to keep up the communication from one part to another round the ends of the traverses, which, however, may be shut by a gate when required. In the more improved systems of Cormontaigne and others, these passages are constructed in such a manner that each can be defended by the fire from the traverse in rear of it.

The *glacis,* as already stated, forms a gentle slope or declivity from the parapet of the covered-way towards the country, and varies from forty to sixty yards. Its parapet cannot be ruined by the fire of the enemy; it covers the revêtement of the body of the place; and being an inclined plane, it can be easily seen and defended from any part of the works.

The *rampart* is an elevation of earth, being the part of the works situated next to the town. It must be thick enough to receive a mound of earth, called the parapet, and also leave sufficient space behind it for working the guns, as well as room for the defenders to pass round freely. The ditch is immediately in front of the rampart, the faces of which are revêted or built up with stone walls, backed interiorly, at every fifteen or twenty feet, by buttresses or counterforts of masonry, to strengthen it. The rampart is divided into the *interior slope,* the *terreplein,* the *banquette,* the *parapet,* and the *exterior slope* or *escarpe.* See fig. 4, *profile.*

The *revêtement* or face of masonry around the work on both sides of the ditch is intended to prevent the earth forming the rampart from falling into the ditch. To ascertain the proper thickness of masonry for this purpose has always been a work of considerable trouble and difficulty. General Sir Charles Pasley of the royal engineers has given the following rules: 1st, For full-scarped revêtements without berms, and for demi-revêtements having berms equal to one-fourth the height of the masonry, the thickness of the wall should be seventeen-sixtieths, and the length of the counterforts or buttresses one-fifth of their height. 2dly, For demi-revêtements without berms, the mean thickness of the wall should be three-tenths, and the length of the counterfort one-fifth of the height. 3dly, For counterscarp revêtements, having only to retain simple terrepleins, the mean thickness should be one-fourth, and the counterfort one-sixth of the height. In all these cases Colonel Pasley supposes the revêtement to be countersloped, that is, to have the exterior slope in a vertical plane, and the interior face inclined, so that the base of the wall may be broader than its upper surface by one-fifth of its height; and he also supposes the counterforts to be rectangular, and the intervals between their centres to be equal to four times their width. 4thly, He recommends that the foundations be made deeper in rear than in front, and that the courses of masonry form an angle with the horizon of about 10° excepting at the exterior points, where it should be made horizontal, to prevent the rain from penetrating, and that the interior face of the wall should be of an irregular form. In order to diminish the lateral pressure of the earth against the revêtements, several tiers of arches may be built between the counterforts in the form of segments of a circle.

The *cordon* is a round projection of stone, about a foot in diameter, which goes quite round the revêtement wall, near the top, and serves to throw the drip of rain off the face of the masonry. It is also a considerable obstacle to besiegers, in placing their ladders for escalade against the escarpe.

The *profile* or *section* of Vauban's first system is given

in Plate CCLX., fig. 4, in order to illustrate the relative relief or height of the respective works, and also to show the command which each has over the others. When the height of the rampart, including that of its parapet, is 20 feet, and that of the parapet of the covered-way is 9 feet above the plane of the site, then the rampart will have a command of 20 feet over the country, and 11 feet over the crest of the covered-way; and the latter, again, will have a command of 9 feet over the field. There are three sorts of command, namely, in front, in rear, and in enfilade. That in front is when any eminence directly faces the work which it commands; that in rear is when the eminence is behind the work; and that in enfilade is when the eminence is situated laterally on the prolongation of any line or work. The last, which is the most dangerous kind of command, is best remedied by raising the salient of works exposed to it (see woodcut 18, p. 775), or by erecting traverses. In drawing this figure, a line, called the line of site, and supposed to be the surface of the ground on which the fortification stands, is drawn, and perpendiculars are erected on it equal to the respective heights of the different parts of the works corresponding to the lines in the figure. Thus *a* shows the terreplein of the rampart, *b* the banquette or step to enable the soldiers to fire over the parapet, *c* the parapet, *d* the revêtement, *e* the escarpe, *f* the counterscarp, and so on.

2. *Vauban's Second and Third Systems.*

Having thus endeavoured to explain, with as much minuteness as possible, the principles of Vauban's first system, we trust, from what has been said, that no great difficulty will be experienced in understanding the methods of other engineers who have constructed works varying but little in the main from those prescribed by this system, whilst even these varieties have arisen from difference of situation and local peculiarities, more than from any other cause. The same general observation, indeed, applies to the other methods of construction followed by Vauban himself, who, in his second and third systems (Plate CCLX. fig. 2), merely modified, according to circumstances, the principles upon which the first is based. When this celebrated military engineer was called upon to repair or improve the fortresses of Landau, Brisach, and others, and found these places already surrounded with strong walls surmounted by small towers at the angles, he did not, as some might have supposed, proceed to destroy these defences, but, with his accustomed judgment and ability, he immediately took advantage of them, and constructed, nearly in the same proportions as in his first system, large counterguards or bastions in front of the towers which crowned the angles of the wall, just as the Italian Castriotto had done in 1584. And by this method an important object was attained; for, as in front of each tower, or rather tower-bastion, there ran a ditch which cut off all communication between it and the counterguard, so the enemy, even if they should have succeeded in establishing themselves in the counterguard, would still have another ditch to cross, and another wall to breach, before they could attempt to give the assault.

There is so little difference between the second and third systems of Vauban, that a description of the former will be sufficient to enable the reader to distinguish and appreciate the peculiarities of the latter. In the second system, the interior side of the polygon, from the centre of one tower-bastion to that of the next, is supposed to be equal to 240 yards, and from its extremities, at the distance of 24 yards, perpendiculars are erected equal to 36 yards, for the flanks of the tower-bastions. A line is then drawn parallel to the interior side AB, till it meets the oblique radius of the polygon, or line drawn from the centre of the polygon bisecting its angle, and this being done on both sides of the angle forms the tower-bastion. The oblique radius is then produced 78 yards, and lines of defence are drawn to the angle where the tower-bastion joins the curtain or line AB. On these lines of defence, the faces of the counter-guard, or exterior bastion, are set off equal to 128 yards, and from the point forming the shoulder, flanks are directed to a point set off on the line AB, at the distance of 70 yards from its extremities. From the salient angles of the tower-bastions arcs are described with a radius of 14 yards for the breadth of the ditch, and tangents to these arcs are drawn parallel to the faces of the tower-bastion, but stopped where they would meet a line drawn from the salient angle of the tower-bastions, at the distance of 20 yards from the flanks.

The *tenaille* is the same as in the first system, excepting that, at its ends, it is carried down till it meets the line drawn between the flanked or salient angles of the tower-bastions. The *ditch* in front of the counterguards, or, in other words, the main ditch, is constructed in the same manner as in the first system. The *ravelin* is formed by setting off 90 yards from the re-entering angle of the counterscarp, and directing its faces to points set off on the counterguards, at the distance of 20 yards from the shoulders. A flank is formed by cutting off the corners of the ravelin at the distance of 14 yards on its demigorge, and 20 on its face; and this flank serves for the placing of guns in such a manner that their fire may be directed into the counterguard, or into the ditch before them, as occasion may require. Again, at the distance of 48 yards from the re-entering angle of the counterscarp, lines are drawn parallel to the faces of the ravelin for the *redoubt;* a ditch is formed in front of this, and parallel thereto, about 18 feet in breadth; and the redoubt thus constructed has a command of 4 feet over the parapet of the rampart, as the tower-bastions have over the counterguards. The *covered-way* and *glacis* are formed as in the first system. It sometimes happens that redoubts are constructed in the re-entering places of arms; in which case their demigorges are made from 15 to 40 yards, and their faces set off at an angle of 100 degrees, as before.

3. *Cormontaigne's System.*

The difference between the systems of Vauban and Cormontaigne may easily be discovered by an examination of Plate CCLX., fig. 3. Vauban makes the faces of his bastions two-sevenths of the exterior side, and Cormontaigne one-third. Vauban, in his first system, produces the faces of his ravelin to the distance of 11 yards upon the face of the bastion from the shoulder, and in his second and third systems, to the distance of 20 yards; but Cormontaigne makes the capital of his ravelins about 120 yards, and produces the faces to the distance of 30 yards from the shoulder; by which means the flanks are better covered, and the bastions and ravelins are enlarged. And this is an advantage; for he is thus enabled to construct a larger redoubt in his ravelin, the curtain and flank are also better covered, and, as the former is shorter, communications are more easily kept up between the bastions. Cormontaigne gives the same breadth to his covered-way as Vauban, but he arranges in a different manner the communication round the extremities of the traverses, as may be seen by inspecting the plate. By this zigzag line of communication, which resembles the cremaillière trace adopted by Speckle in his covered-way, the passage round the extremity of one traverse may be defended by the fire of the other in its rear, or nearer to the body of the place, and the advance of assailants along the covered-way completely checked. As Speckle planned in 1589, or long before the invention of ricochet fire by Vauban had rendered traverses an essential element in fortification, his object was not the same as that of Cormontaigne, but simply to ensure a more perfect flanking defence of the branches of the covered-way than that afforded by the places of arms of his systems. The ditches are, as shown in fig. 3 of this Plate, on different levels—the main ditch being about 23 feet deep, the ditch of the re-

doubt of the ravelin only 7 feet, so that from this latter ditch there is a fall of 16 feet to the main ditch, rendering it impossible to attack the ravelin by its gorge without the aid of ladders. An examination of the several figures which represent Vauban's and Cormontaigne's systems, as also the outworks of fig. 3, Plate CCLXI, will at once render evident the vital defect of the ordinary arrangements of outworks—that they expose by their ditches the scarp of either the body of the place, or of the work on which their faces or branches are directed, to be breached. In the system of Cormontaigne, as well as in the modern system next to be considered, the increased projection of the ravelins, by throwing the intervening bastion into a deeply re-entering position, secures it from attack by approaches until the salients of the ravelins have been taken; but this great advantage is diminished by the power of breaching the bastion from the glacis through the opening afforded by the ravelin. For the purpose of covering the communication to the re-entering place of arms, a *demi-caponnière*, or work composed of a parapet and glacis, was thrown across the ditch of the ravelin, as shown in the figure of the modern system, Plate CCLXI., fig. 2. This work afforded cover also to troops assembling preparatory to a sortie upon the enemy when making the passage of the ditch, but, from the depth of the ravelin ditch, it was insufficient to mask the revêtement of the bastion behind it. It will presently be shown how this object was afterwards effected; and it may be fairly said that without any material change as to system, the general result of Cormontaigne's variations from Vauban's trace is an unquestionable improvement.

4. *The Modern System.*

The modern system, which is shown in Plate CCLXI. fig. 2, varies but little from Cormontaigne's. Its perpendicular is one-sixth of the exterior side, and the faces of the bastions are one-third. The flanks are at right angles with the lines of defence, whereas in Vauban's system they form an angle of about eighty-two degrees; which is not so good, because, in the modern system, the guns placed in the flanks can fire straight along the ditch without being moved or turned on their platforms. The ravelin is formed by setting off thirty-four yards from the shoulder angle of each bastion along the face, which line forms one side of an equilateral triangle, the vertex of which, opposite the centre of the curtain, forms the salient angle of the ravelin. The redoubt of the ravelin is formed by drawing its faces parallel to those of the ravelin from the shoulder angle of the parapet of the bastion; and it has flanks with a ditch about twenty yards in breadth. The *cavalier* in the bastion is drawn parallel to the faces of the bastion, at the distance of forty-eight yards. The ditch on the faces is ten yards in width, but there is no ditch on the flanks. The *coupure* connected with the cavalier retrenchment is drawn perpendicular to the faces of the bastions, at thirty-four yards for the counterscarps of the coupures, whilst the scarps are at ten yards, and parallel to these. This system originated in the School of Military Engineering instituted at Mézières in 1750, and was for some time called the System of the School of Mézières. It has, however, been successively much improved; and the system which is now recognised as the modern system is that of General Noizet. Referring, however, to fig. 2 of the Plate, it will be seen that coupures have been introduced on the faces of the ravelin; and as the ditch of the ravelin in this system has by many engineers been sunk less by 7 or 8 feet than the main ditch, there is a sufficient fall between the two to check the enemy in his passage to the latter, whilst the demi-caponnière is raised so much higher, and therefore begins to mask more effectually the revêtement of the bastion. In General Noizet's system this demi-caponnière is formed into an elevated mask, which effectually secures the revêtement from the breaching effect of the fire from the enemy's battery on the crest of the ravelin glacis. This is shown in the annexed woodcut; and the system modified from the former modern system in this respect, as well as in other arrangements, is now the normal bastioned

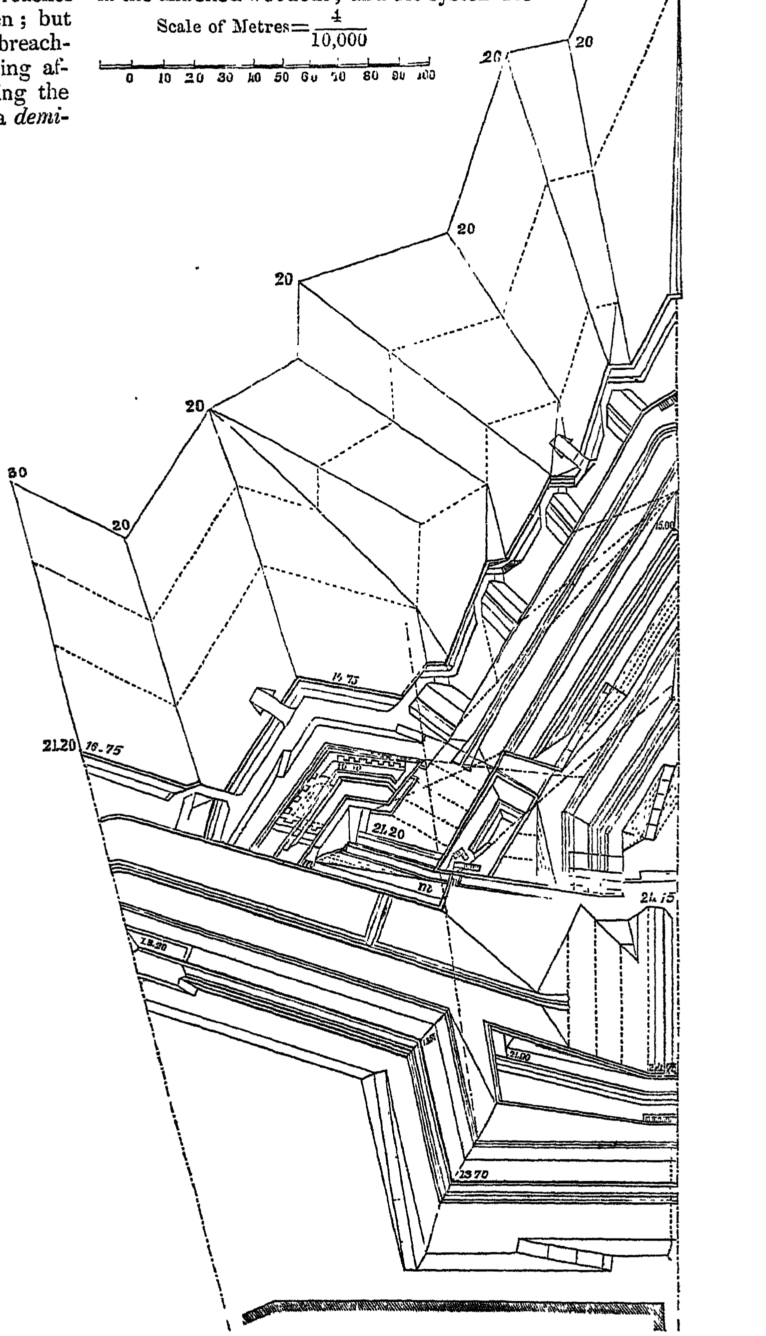

Fig. 33.

system of all the French schools. In General Noizet's arrangement the flanks are not made perpendicular to the lines of defence, but, as in Vauban's first system, the flank forms an angle of about 80° with the line of defence. In the citadel of Ghent, which is a most beautiful example of this system, with still further modifications, the retrenchment of the bastion is so formed as to take advantage of this construction, and the flanks being casemated and pierced in both directions, they become on one side the flanks of the retrenchment, whilst on the other they are the ordinary flanks of the bastion, thus giving a much longer curtain to the retrenchment than in the form exhibited in fig. 3 of Plate CCLXI., as it occupies the whole gorge of the bastion.

5. *Outworks.*

Plate CCLXI., fig. 3, shows several kinds of outworks, as a horn-work *g*, tenaillons *k* and *k*, bonnet *d*, lunettes *a* and *d*, an entrenched bastion *e*, batardeau *f*, and caponnière *h*. These, and other works of a similar description, are constructed for the purpose of occupying some of the ground which might otherwise be of service to the besiegers, or as in the caponnière to cover a communication; but their application must of course depend upon certain localities, and the judgment of the engineer must therefore determine, in each particular place, which is best adapted to the ground, and most proper to be employed with reference to the general defence of the place.

ARMAMENT OF FORTRESSES.

Having thus described, though briefly, the systems of fortification which, mainly depending on the principles first adopted by the early Italian engineers, may be considered the result of the gradual development of these principles in the more mature and skilful arrangements of successive engineers, it is right before describing other systems to say a few words respecting the means of defending a place after it has been fortified. And here we may observe, that it is difficult to lay down any exact rules as to the proportion of ordnance, ammunition, and stores of every kind required for the defence of a fortified place, seeing this must necessarily vary according to the particular situation of each fortress, the system on which its works have been constructed, and the species of attack to which it may be exposed. If, for example, one of the sides be covered by a morass, swamp, or any other obstruction which it is difficult or perhaps impossible to surmount, it must be obvious that, in this case, a smaller proportion of artillery will be required than if the fortress were equally accessible on every side; and, on the other hand, a maritime fortress, accessible at all points, will necessarily require for its defence a larger proportion of ordnance than if it were only assailable on one or a few of these points. Where every front is equally exposed to attack, all must of necessity be equally prepared.

On this subject, however, there have been established certain maxims, of which the following appear to be the most important: First, the proportion of ordnance, ammunition, and stores, should never exceed the quantity necessary for a brave and resolute defence. Secondly, those points which are considered as being most exposed to attack should be most completely armed, whilst the partial armament of the remaining points may suffice. Thirdly, for each of the faces of the bastions which are liable to be attacked, five or six pieces of ordnance should be allotted; for each of the flanks of these bastions, four; for the faces of the ravelins, from five to seven; for the lunettes, when there are such, four pieces of ordnance should be reckoned; besides two or three pieces for each of the places of arms in the covered-way. Supposing, therefore, that one front of a place is to be completely armed, the proportions of ordnance required will be, for the faces of the bastions from ten to twelve pieces, for the two interior flanks from six to eight, for the faces of the ravelins from five to seven, and for five places of arms from ten to fifteen; making the total of ordnance for one front from thirty-one to forty-two pieces. Fourthly, when a place is exposed to attack on two consecutive fronts, the armament of each should be augmented one half; when it is threatened with attack on detached fronts, the armament should, in that case, be doubled. Fifthly, each of the other fronts should merely be provided with such a proportion as to secure it against insult. Lastly, from the foregoing maxims, it appears that a hexagon, having only one front exposed to attack, requires from fifty-eight to sixty-eight pieces of ordnance on such front, whilst in more extensive places, six, eight, or ten pieces should be added for each additional front. For the present increased power of the ordnance brought into the field this proportion should be increased by about $\frac{1}{10}$th of the total number.

The next consideration is the proportion which the several kinds of ordnance should bear to one another. And here let it be remembered that ordnance of the higher calibres is not the only description which ought to be employed. In many cases medium and even light guns are more efficacious; for when only troops or working parties are to be fired at, light guns will answer every purpose, as the range of the shot is nearly equal to that of larger guns, and they are of course much more manageable, and may be worked with greater rapidity. But short guns of heavy calibre are best adapted for the flanks; and, generally, the large or heavy ordnance should only be employed to destroy the besiegers' batteries and dismount their guns. The flank guns being only required for the defence of the ditch, short pieces of large calibre, as carronades, which throw a heavy charge of grape or canister shot, are the most proper to be employed. The light guns, as they can easily be withdrawn, should be placed on the covered-way and places of arms, and on outworks of every description. The heavy long guns and mortars, as they are not so easily moved, should be within the body of the place, and as they require a great quantity of ammunition, they should be less frequently used, and only upon urgent occasions. A judicious economy of ammunition is a duty incumbent upon every governor or commandant of a fortified place attacked. The conduct of General Chassé in the defence of the citadel of Antwerp was a model in this respect. From the commencement till the close of the attack, scarcely a single shot was needlessly expended by the garrison.

ATTACK AND DEFENCE OF FORTIFIED PLACES.

Having thus treated of that important branch of fortification which is denominated permanent, and which, being applied solely to the defence of towns, is not liable to be destroyed except by an enemy, we now proceed to consider the attack of fortified places, the general system of which was introduced by Vauban, and so far perfected by that great engineer that it has ever since served as a model for the plans of his successors.

"La résolution des sièges," says the Mareschal, "est une affaire de cabinet. Elle est une suite naturelle de la supériorité que l'on croit avoir sur ses ennemis; mais leur exécution étant une des plus sérieuses, des plus importantes, et des plus difficiles parties, elle demande aussi le plus de mésure et de circonspection." He then goes on to state that the success of sieges depends on several circumstances, such as, "1. Du secret, sans lequel il est difficile de réussir: 2. Des forces que l'on a sur pied pour attaquer les places des ennemis, et défendre les siennes: 3. De la disposition des ennemis; car s'ils sont réunis, et aussi forts que nous, ils peuvent nous empêcher d'en faire: 4. De

l'état des magazins les plus à portée des lieux sur lesquels on peut entreprendre: 5. De la conjoncture des tems, parce que tous ne sont pas propres aux sièges, et rien n'étant plus ruineux que ceux d'hyver, on les doit eviter tant qu'on peut: 6. Des fonds nécessaires à leurs dépenses; car l'argent est le nerf de la guerre, sans lui on ne sçauroit réussir en rien. Ce sont là des mésures à prendre de longue main, qui doivent être dirigées à loisir; et aprés tout cela, quand on croit les avoir bien prises souvent tout échappe; car l'ennemi, qui n'est jamais d'accord avec vous, pourra vous interrompre..... Il faut bien peser toutes ces considérations, avant que de se déterminer; et prendre toujours si bien son tems, que l'ennemi ne puisse vous tomber sur les bras avant vos établissemens."[1]

A siege, therefore, being one of the most arduous undertakings in which an army or corps d'armée can be employed—one in which the greatest fatigue, hardships, and personal risk are encountered, and in which the prize can only be won by complete victory; it is obvious that, upon the success or failure of such an enterprise may depend the fate of a campaign, sometimes that of an army, and perhaps even the existence of a state. Of this the failures before Pavia in 1525, before Metz in 1552, before Prague in 1557, before St Jean d'Acre in 1799, and before Burgos in 1812, present instructive examples. By the first, France lost her monarch, the flower of her nobility, and all her Italian conquests; by the second, she was saved from destruction, whilst thirty thousand of her enemies perished; by the third, the greatest warrior of his age, Frederick the Great, was brought to the very brink of destruction; by the fourth, the most successful general of France, and perhaps the greatest commander that any age or country has produced, was stopped short in his career of victory; and by the last, a beaten enemy gained time to recruit his forces, concentrate his scattered corps, and regain that ascendancy of which the victory at Salamanca had for a time deprived him. Innumerable other instances of the disastrous consequences usually attendant on the failure of sieges might easily be produced; but those which have just been referred to are sufficient to establish the importance of the undertaking, and to show that the dearest interests of a country may frequently be staked on the sure and speedy reduction of a fortress.

It is therefore of the greatest importance to a state that the sieges undertaken by its armies should be carried on in the best and most efficient manner possible, or, in other words, that by a due combination of science, labour, and force, these operations should be rendered not only short, but certain, and unproductive of any great expenditure of life. But the sieges undertaken by the British have almost never united these three indispensable conditions; and with regard to those which took place during the contest in the Peninsula, it is well known that various defects of organization, and particularly the want of a body of men such as sappers and miners, trained to the labour required at sieges, and an inadequate supply of matériel, necessitated a partial departure from established principles and rules of attack, and consequently led to a waste of life wholly unprecedented in modern sieges. Till late in 1813 the army was unattended by a single sapper or miner: regular approaches were therefore difficult if not impracticable: it was necessary, in almost every case, to take the bull, as the saying is, by the horns; the last operation of a siege scientifically conducted, namely, battering in breach, was amongst the first undertaken: and the troops were marched to the assault whilst the defences remained nearly entire, and exposed to every species of destruction which the unreduced means of the besieged could bring to bear against them. The army of a country which has outstripped all others in the useful arts and in mechanical improvements, was left wholly unprovided with those appliances which at once economise labour and life, and serve to render both most effectual for the purposes to which they are applied. But, notwithstanding this great anomaly, which is chargeable against the government alone, and not against either the nation or the army which in the most adverse circumstances so nobly sustained its reputation, it may be observed that, in all periods and in all countries, the means employed for the reduction of fortresses have generally increased and become more overwhelming and irresistible in proportion to the advancement of knowledge and the improvement of the useful arts; and that in Europe during the last two centuries, the extensive diffusion of wealth and knowledge, accompanied by an unprecedented development of talent, all more or less directed towards military movements, has caused the results of sieges, and indeed of almost all the operations of war, to depend much less on individual exertion or casual displays of heroism, than on mere combination and expenditure. This may be made apparent by a slight retrospect of the sieges of the sixteenth century.

At the period here referred to, the art of disposing the several works of a fortress so as to cover each other, and to be covered by their glacis from the view of an enemy, was either unknown or disregarded; whilst the small quantity of artillery in use, its unwieldiness, and the great expense and difficulty of bringing it up, occasioned so little to be used in sieges, that the chief object in fortifying towns was to render them secure against escalade and surprise, by means of lofty walls or altitude of situation. All places fortified prior to the sixteenth century are invariably of this construction. And as the simplicity of the fortresses to be attacked necessarily gave the same character to the operations directed against them, so, in those days, everything was effected by daring courage, without the aid of science; and gallantly contending in individual combat, or fearlessly confronting danger, were considered as the highest qualities of a besieger. Thus the contest dragged on for months, in petty but sanguinary affairs, and the most persevering or the most hardy troops, however ill organised or supplied, were the most dreaded, and not unfrequently the most successful. But when artillery became more moveable, and large quantities began to be employed in sieges, lofty and exposed walls no longer opposed any adequate barrier; large breaches were speedily effected; places which had formerly resisted for months were carried in a few days; and hence, in order to restore an equality of defence, it became necessary to screen the ramparts from distant fire. The attempt to gain security by concealment rapidly advanced towards perfection, whilst the means of the besiegers remained the same; and between the middle of the sixteenth and commencement of the seventeenth century, works were so skilfully disposed and so well covered, that the defence of towns obtained a temporary superiority over the attack as the latter was then practised. Of this the obstinate and successful defences made by the Dutch against the Spaniards during the reigns of Philip II. and Philip III. may be cited as remarkable examples.[2]

The pre-eminence of the defence over the attack was mainly due to the great difficulty of dragging up heavy ordnance with a besieging army, so that the weight of metal being generally in favour of the besieged, the fire of the fortress was enabled to keep in check that of the batteries of attack. Vauban, however, in the reign of Louis XIV., restored the preponderance of power to the attack by the invention of ricochet fire, as the guns of the besieged were

[1] *De l'Attaque et de la Défense des Places*, pp. 1 and 2. Hague, 1737, 4to.
[2] *Journals of Sieges in Spain*, by Colonel Sir John T. Jones; *Preliminary Observations on the Attack of Fortresses.*

thereby dismounted or disabled at an early stage of the siege, and the besiegers were enabled to push forward their approaches by the sap, being relieved in great measure from the dangers and difficulties of a direct and powerful opposing fire of artillery. Vauban also matured into a system the attack by laying down rules for the establishment of parallels, for the location of enfilade and other batteries, and for the general conduct of the approaches. The real type of an attack is a *moving parapet*, the besieger carrying on with him his cover, and thus depending for his success not so much on his offensive as on his defensive arrangements. It was by this combination of science and labour, aided by the steady advances of brave and well-trained sappers, that the reduction of fortresses, which would have resisted for ever the rude assaults of the most determined enemy, was rendered comparatively easy and certain.

These increased means of attack, to which it was found impossible to oppose a successful resistance, caused the art of concealment or covering to be further studied, till at length, in well-constructed fortresses, not a single wall remained exposed to view, and the sap and the mine became as necessary as the gun and the mortar to the success of a besieger. To render this intelligible to the general reader, it may be proper to introduce here a descriptive sketch of the progress of a modern attack, from the excellent work of Sir John Jones, already referred to.

"The first operation of a besieger," says that able and experienced engineer, "is to establish a force able to cope with the garrison of the town to be attacked, at the distance of six or seven hundred yards from its ramparts. This is effected by approaching the place secretly in the night with a body of men, part carrying entrenching tools, and the remainder armed. The former dig a trench in the ground parallel to the fortifications to be attacked, and with the earth that comes out of the trench raise a bank on the side next to the enemy, whilst those with arms remain formed in a recumbent posture, in readiness to protect those at work, should the garrison sally out. During the night this trench and bank are made of sufficient depth and extent to cover from the missiles of the place the number of men requisite to cope with the garrison, and the besiegers remain in the trench during the following day, in despite of the fire or sorties of the besieged. This trench is afterwards progressively widened and deepened, and the bank of earth raised till it forms a covered road, called a parallel, embracing all the fortifications to be attacked; and along this road, guns, waggons, and men securely and conveniently move, equally sheltered from the view and the missiles of the garrison. Batteries of guns and mortars are then constructed on the side of the road next the garrison, to oppose the guns of the town, and in a short time, by superiority of fire, principally arising from situation, silence all those which bear on the works of the attack. After this ascendancy is attained, the same species of covered road is, by certain rules of art, carried forward, till it circumvents or passes over all the exterior defences of the place, and touches the main rampart wall at a spot where it has been previously beaten down by the fire of the batteries erected expressly for the purpose in the more advanced parts of the road.

"The besiegers' troops being thus enabled to march in perfect security to the opening or breach in the walls of a town, assault it in strong columns; and being much more numerous than the garrison defending the breach, soon overcome them, and the more easily as they are assisted by a fire of artillery and musketry directed on the garrison from portions of the road only a few yards from the breach; and which fire can, at that distance be maintained on the defenders of the breach until the very instant of personal contention, without injury to the assailants. The first breach being carried, should the garrison have any inner works, the covered-road is by similar rules of art pushed forward through the opening, and advanced batteries are erected in it to overpower the remaining guns of the place; which effected, the road is again pushed forward, and the troops march in security to the assault of breaches made in a similar manner in those interior works, and invariably carry them with little loss. But as it is always an object to preserve the life of even a single soldier, so, when time is abundant, the loss of men attendant on the assault of breaches under these favourable circumstances may be avoided, by pushing up the covered-road through the breach, without giving the assault, and thus, by art and labour, the strongest defences frequently fall without any exertion of open force."

From this description it must be obvious that the most important object at a siege is to carry forward the covered-road to the walls of the place; that all the other operations are secondary to and in furtherance of such an advance; and that hence the efficiency of armies at sieges depends upon their ability to complete the road at a small expense of life. But in forming this covered-road, different degrees of difficulty are experienced in proportion as it advances. At its commencement, the work being about six hundred yards from the fortifications, can easily be performed by the common soldiers. But when the road or trench has arrived within a fair range of musketry, or three hundred yards from the place, then particular precautions are required; yet the work at this stage is not so difficult as to prevent its being executed by soldiers who have had a little previous training. At the last stage, when the approaches have been pushed close to the place; when to be seen is to be killed; when mine after mine blows up the head of the road, with every officer and man on the spot; when the space becomes so confined that little or no front of defence can be obtained; and when the enemy's grenadiers sally forth every moment to attack the workmen, and deal out destruction to all less courageous or weaker than themselves; then the work becomes truly hazardous, and can only be performed by selected brave men, called sappers, who have acquired the difficult and dangerous art from which they derive their name. An indispensable auxiliary to the sapper, however, is the miner, who, in the exercise of his art, requires even a greater degree of skill, conduct, and courage. The duty of a miner at a siege is to accompany the sapper, to listen for and discover the enemy's miner at work, and to prevent his blowing up the head of the road, either by sinking down and meeting him, in which case a subterranean conflict ensues, or by running a gallery close to that of his opponent, and forcing him to desist from working by means of suffocating compositions, and various arts of chicanery, the knowledge of which he has acquired from experience. Without the aid of skilful miners, sappers would be unable to execute that part of the covered-road forming the descent into the ditch, not to mention other operations in the progress of which the assistance of the miner is equally indispensable; and without their joint labours and steady co-operation, no besiegers' approaches ever reached the walls of a fortress. In the British service, indeed, they are blended into one honourable body, the Sappers and Miners.

But a siege, though it calls for great personal bravery, unremitting exertion, and extraordinary labour in all employed, yet, if scientifically prosecuted, is alike certain in its progress and its result. More or less skill and exertion in the contending parties may in some degree prolong or abridge its duration; but the sapper and the miner, when skilfully directed and adequately supported, will ultimately surmount every obstacle. On the other hand, sieges undertaken by armies imperfectly supplied with these auxiliaries, as the British army once was, are hazardous in the extreme. Their only chance of success consists in scrutinizing the exterior of a fortress, in order to discover some spot whence, from the irregularity of the ground, or fault of con-

struction, the main escarpe wall may be seen at a distance sufficiently great to enable the ordinary working parties to approach with the covered-road, and there to establish batteries for breaching the wall or forming an opening through it into the place. When this is effected, the troops at once advance to the assault of the breach, as in the sixteenth century, thus losing the shelter of the covered-road at the moment when the fire of the place becomes most powerful and destructive; and as the fire of the besieger's distant batteries is necessarily suspended during the assault, in order to avoid killing their own storming party, the garrison can therefore with impunity mount their ramparts and employ every kind of weapon, missile, and instrument in their defence. All the chances are thus in favour of the besieged; for should the columns of attack, under all these disadvantages, arrive in good order at the brink of the ditch, they must descend into it by a wall from fourteen to sixteen feet in depth, which cannot fail to break their order and throw them into confusion; and as no new formation can be attempted in a spot where death is incessantly showering down on them, the assailants rush to the breach more like a rabble than a solid column. From this moment success hinges on the individual and confident bravery of the officers and troops, and the unshrinking firmness of the general commanding, in at once encouraging and supporting their efforts. But although these qualities, when united in a high degree, may, at a great sacrifice of life, enable the assailants to overcome all resistance, yet an assault of this nature, attempted under ordinary circumstances and feelings, has almost invariably proved unsuccessful. Indeed it may be laid down as the general result of experience, that should an army unprovided with sappers and miners, and the necessary materials and means to render their services efficient, be opposed to a place fortified according to the modern system, with its walls completely covered, all the usual methods to reduce it would prove unavailing; no period of time nor sacrifice of men would be sufficient to purchase success, and the prudent course would be to decline an attempt pregnant with hazard, perhaps ruin.

"These considerations," says Sir John Jones, to whom we are indebted for the above account of the various modes of attacking fortified places, "have for many years had their due weight with the great powers of Europe, and induced them to form and keep up, as integral portions of their military strength, every necessary auxiliary for the reduction of fortresses; and their sieges have in consequence become certain and comparatively bloodless. But England, constitutionally jealous of permanent military establishments, always discountenanced military organization and military preparation till the hour of need; and with respect to sieges, they being of rare occurrence, and moreover exclusively offensive operations, even carried her jealous feelings beyond the bounds of rational prudence; for, possessing a corps of officers professionally educated and well grounded in the science of attack and defence, she denied them every requisite establishment to render their acquirements availing, and most unreasonably expected her armies to reduce the skilfully fortified and well-covered places of the nineteenth century with means inferior to those brought against the exposed and ill-constructed places of the sixteenth and seventeenth centuries." And what was the immediate consequence of this irrational jealousy and niggardly parsimony? Contrary to all ordinary calculation, the fortresses garrisoned by the French in Spain were reduced; but at what a prodigious expenditure of life was this effected? In the several attacks upon Badajoz, two of which, from extrinsic circumstances, proved abortive, a little army was sacrificed; as many men, in short, as would have been sufficient for the consumption of *ten* sieges undertaken with adequate means, and conducted according to the ordinary rules of science. But this is not to be understood as involving any reflection against the military talents of the general or the professional ability of the engineers. General Foy, in his work on the war in the Peninsula, has indeed made such a charge, condemning the mode of attacking fortresses adopted by the British in Spain as unskilful and inefficacious, and bringing it forward as indisputable proof of the low state of military knowledge in our army. But it should be recollected that the adoption of this mode was not a matter of choice, but of necessity; and that if it was in its own nature rash, hazardous, and inefficient, the fact of its having been directed against Ciudad Rodrigo and Badajos with such rapidity of development and certainty of result as to outstrip the calculations of the French marshals, deceive the vigilance of French governors, paralyse the science of the French engineers, and baffle every defensive effort of the French garrisons, is surely no evidence of deficiency in military talent and professional skill. The objections to this mode of attack are insurmountable and decisive; that it succeeded in the instances referred to is merely a proof what British soldiers, even when acting under the greatest disadvantages, are capable of accomplishing. The force of the remarks of Sir J. Jones has not become less by the progress of time, as the present war found us, not indeed so deficient in well-trained sappers as we were at the commencement of the last, but equally so in all the most important elements of modern organization, and, as regards this special branch of the service, not yet determined as to what the field equipment of the engineer establishment ought to be. We have still to learn the importance of that scientific knowledge which would enable the engineer to vary that equipment so as to meet the necessities of the geological structure of each particular country.

Having thus given a general description of the methods of attack, we shall now subjoin, on high authority, a view of what is considered as necessary for the proper defence of fortified places. An order issued by the French minister of war in 1813 contains directions on the subject which are almost universally applicable, and therefore deserve a place here. Every commander is directed to consider his garrison as liable to be unexpectedly attacked, and to pass at once from a state of peace into one of war or siege, either by rebellion, by unlawful assemblies, by the presence of an enemy, by surprise, or by sudden assault; in a word, by unforeseen causes, of which the history of war offers numerous examples. He is therefore ordered, even in time of peace, to fix his plan and arrangement for defence, according to such supposed attacks as may appear most probable, and to determine, for the principal cases which may be likely to occur, the necessary posts, reserves, and movements of the troops, and to take measures to ensure the due and active co-operation of every corps of the garrison. He ought, particularly, to make himself thoroughly acquainted with, *first*, the ground beyond the place which may be within the circle of action, of investment, and of attack; *secondly*, the fortifications of the place, its interior, its buildings, its military edifices or establishments; *thirdly*, the garrison, the means of the place in artillery, in ammunition, and in other stores of every kind; *fourthly*, the population to be subsisted in time of siege, the men capable of bearing arms, the master and journeymen artificers fit to be employed either on the works or in case of fire; and, *fifthly*, the provisions, materials, tools, and other resources which the town itself and surrounding country can furnish, and which it might be necessary to secure in case of siege. In order to enable governors and commanders to comply with these instructions, which are equally clear and precise, the minister proceeds to detail their principal duties, according to the circumstances in which they may find themselves placed; but for these we must refer to the general order itself, which is a masterpiece of its kind, and in all probability emanated directly from Napoleon himself. Its object appears to have

been to inspire a governor with hopes, that by taking proper precautions, and making a full use of means previously provided, the defence might be rendered equal, if not superior, to the attack; and although it is still considered that the idea of attaining such an advantage for the defence is far from being realised, yet the importance of the directions embodied in the order is not on that account diminished, and where they are duly observed, the nature and extent of the resistance must be materially increased.

The protracted and able defence of Sebastopol will doubtless lead many to doubt the accuracy of the opinion thus stated, and to imagine that the Russians have by some new defensive arrangements solved the problem so long under discussion, and again restored to the defence its former superiority over the attack. This idea has indeed so taken possession of the public mind, that already persons have been found ready not only to assert the supposed fact, but also to explain the mode in which the improvement has been effected: whenever Sebastopol shall fall, and as regards the southern defences, the period of such fall seems approaching, this delusion will doubtless be dispelled, and the real merits of the Russian engineers will be found to consist not in the discovery of new principles, but in the skilful application of those principles which, recognised at an early period, have been by degrees matured and enlarged. In estimating the comparative results of the attack and defence of Sebastopol, it must also be remembered that neither can be judged by strict rules, as neither has conformed to such rules. The north side being left open by the impossibility of fully investing the whole line of defences, the south became a detached line of powerful intrenchments, upon which the whole force of an army, not of a garrison, could be directed at will in its defence. In another point, also, the attack has not had its usual advantage, not having been able to use, with the customary effect, the enfilading ricochet fire, as the disposition of the line of works was such as not to offer sufficiently salient points, and therefore to leave so much to be done by direct fire. The unlimited extent of the garrison, being capable of continued renewal from the external army, has permitted the use of detached forts or works which, when backed by a line in rear of them sufficiently strong to resist a *coup-de-main*, constitute one of the most powerful modes of defence. Such a fort or work is the celebrated Malakoff Tower, and the redoubt enveloping it, the type of which may be found in the Lunette of Darçon, of which fig. 39 is a plan. In this lunette,

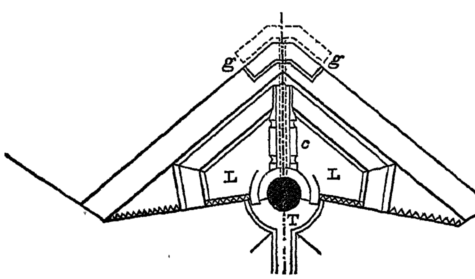

Fig. 39.

intended to be prepared beforehand, T is a powerful tower, LL a lunette, in this case revêted, but which might have been made, as at the Malakoff, a simple earth-work—*c* an underground communication to *gg*, loopholed galleries for flanking the ditches. This little sketch will show the general principle of defence involved in such works, but of course the form must vary in the hands of an able engineer, so as to suit the peculiarities of the ground. At the Malakoff the redoubt has been made circular, but as to principle it is strictly analogous to the lunette. Hereafter, without doubt, the details of this remarkable siege will become the study of military men, but at present it is necessary to select some other example, as there is as yet far too much uncertainty as respects the exact form, construction, and position of the works of Sebastopol to enable an engineer to reason with certainty upon them.

Siege of the citadel of Antwerp.

For the elucidation, then, of the attack, we shall now proceed to give a sketch of the attack on the citadel of Antwerp; first, because this was the most regular and scientific siege which had taken place for many years; and, secondly, because, as a practical operation, an account of it must not only be more interesting, but at the same time more instructive, than any description whatsoever of the formal theoretical plans which are usually drawn in the military schools.

The French army employed to cover and conduct the attack of the citadel of Antwerp, in November and December 1832, was placed under the command of Marshal Gerard, and amounted to 54,000 infantry, 6000 cavalry, and 6450 engineers, artillery, and pontonniers, making a total of 66,450 men, and 14,300 horses, with 144 pieces of siege, and 78 of field artillery. On the 24th of November Marshal Gerard established his head-quarters at the village of Berchem, about 2500 yards from the citadel, and issued orders to commence operations in the evening as soon as it became dark. The garrison of the citadel, under General Baron Chassé, amounted to 4470 men, with 144 pieces of ordnance of all calibres, and abundance of ammunition and stores.

It will be observed here that a garrison of about 5000 men was opposed to the attack of a besieging army thirteen times its strength.

At eight o'clock P.M. on the 29th November the French troops destined for this service consisted of 18 battalions, 900 artillery, and 400 sappers, in all about 17,140 men, assembled at the depôts of intrenching tools. The flank companies of these brigades, supported by twelve eight-pounders and a strong piquet of cavalry, formed the covering party under the direction of General Haxo, by whom and the officers of his department (the engineers) the first parallel and approaches were traced out, whilst General Niègre and the officers of artillery marked the sites of the projected batteries. The first parallel leaned on the covered-way of the right face of Montebello, and extended towards Kiel, its nearest point being about 325, and its farthest 435 yards from the advanced front of the citadel. The distance covered by the first parallel, from right to left, was 1870 yards, and that by the approaches 3750 yards. The communications from the right and centre debouched from the Malines Chaussée, in the village of Berchem, parallel to the road leading from that village to the Harmony and St Laurent; that from the left commenced near to the garden called Heinrich's; whilst a fourth, on the extreme right, sprung from the covered-way of the left flank of Montebello, opposite to the first traverse.

On the second night, from 30th November to 1st December, five approaches were pushed on in front of the first parallel; two in the direction of the capital of the Toledo bastion, two upon that of the Lunette St Laurent, and one, being the fifth, terminating in a place of arms on the extreme left. From the 1st to the 2d December two zigzags were added to the approaches; one from the centre, in the direction of the gorge of St Laurent, and the other on the right, diverging towards the curtain, between the Toledo and Fernando bastions. The badness of the weather sadly incommoded the workmen, and prevented the artillery getting the guns into battery. Between the 2d and 3d December four zigzags were made in front of the approaches on the right and centre, and half a parallel was formed to complete the place of arms constructed on the left during the night of the 30th November. The heads of the zigzags were pushed to within 135 yards of the glacis. The batteries Nos. 1, 2, 3, 4, 5, 6, and 9, with two for mortars

in the rear, were armed, and ready to be unmasked at a moment's notice. The arming of Nos. 7, 8, and 10, on the extreme left, was impeded by the difficulties of the ground. From the 3d to the 4th December, the second parallel was traced and commenced, its right leaning on the foot of the glacis of the counterguard, its centre and right 130 yards distant from the place of arms in the covered-way of the Toledo bastion, and its left towards the right of the covered-way of St Laurent, at 90 yards from the crest, and 15 from the foot of its glacis. The length of the second parallel was 1250 yards, and, together with its approaches from the first parallel, it occupied 3025 yards of ground. By the greatest exertions batteries Nos. 7, 8, and 10 were armed during the night. This completed the armament, and, at 11 A.M. on the 4th, the embrasures were unmasked, and the signal being given, the batteries opened their fire from centre to flanks, and maintained it steadily during the day.

From the 4th to the 5th of December an approach was pushed on from the second parallel, almost in a direct line upon the salient angle of St Laurent, and an entry was made into the covered-way by a return to the left. The garrison discovered this, and opened a sharp fire from the lunette; a lodgment was, however, effected near the spot usually occupied by the first traverse. At this time the garrison suffered much from the fire of the besiegers. From the 5th to the 6th the lodgement made the previous night in the covered-way of the salient place of arms of St Laurent was prolonged as far as the first traverse. But the besieged kept up so vigorous a fire that the French engineers were obliged to renounce the flying and adopt the full sap. The zigzag in the counterguard, being about three feet in width and four in depth, was conducted along the parapet, nearly to the extremity of the right flank, and within 180 yards of the counterscarp of bastions Toledo and Fernando; and two lodgments, blinded with fascines, were made in the parapet for six rampart guns to enfilade the covered-way of the Toledo bastion. In the meantime a steady fire was kept against Kiel, the ravelin in its rear, and the Paciotto bastion. From the 6th to the 7th a battery of 24-pounders near the village of Burcht on the left and Hoboken on the right opened on the gun-boats which flanked the French post at the Melk Huys. It was intended to assault St Laurent this evening; but as the lunette was found to be too well protected by *trous-de-loup*, the project of storm was abandoned, and the regular method of descent, passage, and mine, determined on.

Between the 7th and 8th of December a shell penetrated the blindage of the laboratory, and setting fire to loaded bombs and other combustibles, caused considerable havoc. A battery for six mortars, E, on the right between Nos. 3 and 4, now opened its fire; another, F, also for six mortars, was traced behind the centre of the parallel; and platforms for four mortars were laid down near Montebello. The fire of these batteries was directed on the Toledo bastion and the buildings within it. On the previous day jets of smoke and flame were seen to issue from the Great Barracks, and, in spite of every exertion on the part of the garrison, the whole building soon became involved in a general conflagration, which raged with such fury, that by the evening of the 8th it was entirely consumed.

From the 9th to the 10th of December the operations against St Laurent were renewed with great activity, and the sap advanced to the crotchet of the second traverse, whilst that intended to debouch upon it from its right was likewise pushed on. The principal operation of the night, however, was the opening of the third parallel, 130 yards in advance of the second, its right debouching beyond the Boom Chaussée, from the branch running into the covered-way of the counterguard, and its left uniting with the boyau parallel to the foot of the glacis of St Laurent. At this time the garrison suffered much from the vertical fire of the mortars and howitzers, especially the great mortar, and the new-model eight-inch howitzers. Until the year 1822, the eight-inch howitzer in common use in France measured three feet six inches French, and weighed 1096 lb., or twenty-three times the weight of the loaded projectile, whilst its calibre was equal to a solid shot of 80 lb., and contained 65 ounces of powder. The new-model howitzer is an improvement on the Russian licorne and the Spanish heavy howitzer, perfected by Colonel Paixhans. The raft for the blinded descent into the ditch was brought up to the lodgment, and a second descent *à ciel couvert* was commenced to the left of the first. The third parallel was, at the same time, improved and widened. A little after dusk on the 10th the besieged made a sortie, which was driven in, but not until damage enough had been done to occupy the French all the night of the 10th and morning of the 11th in repairing it. From the 11th to the 12th three rafts were got ready, and placed in the descents to the ditch; they were about twelve feet by eight. At dusk the miners returned to the escarpe, and, in an excavation made the previous night, fixed two petards, which, by their explosion, produced a fissure in the wall; and a serjeant having immediately entered the hole, commenced a gallery under the centre of one of the arches. At 11 A.M. on the 12th the battery mortars, H, on the extreme right of the second parallel, opened their fire, which, combined with that from the others, told severely on the Toledo bastion. The miners still continued their work under the lunette St Laurent, and commenced chambers for three mines. The fourth parallel was widened during the day.

Between the 12th and 13th of December the miners were at work in the chambers under St Laurent, which were not yet completed. On the right the covered-way of the left face of the Toledo bastion was crowned to within sixty-five yards. From the 13th to the 14th, after nearly sixteen nights of open trenches, the arrangements for the assault of St Laurent were completed, and orders were issued to prepare for the storm. Much, a great deal too much, was said of this out-work, defended by little more than a hundred men, one five-and-a-half inch howitzer, two coehorn mortars, and a six-pounder. The mine being reported charged, the blinded descent into the ditch was pierced as soon as it became dark, and everything got ready for the assault. Three storming parties, consisting of the flank companies of the 65th regiment of the line, were posted in readiness, with a column of reserve; and at 5 A.M. on the 14th, every preparation being completed, the match was applied to the saucissons of the mines. After a few moments of suspense, three successive explosions took place, and the escarpe immediately presented a wide and practicable breach. The fascines for crossing the ditch had been injured by the explosions; but after a little delay the storming party entered almost without opposition, and made prisoners one lieutenant and forty-eight rank and file, the others having escaped into the citadel. Thus fell the lunette St Laurent.

After this operations were carried on against the citadel, and at 11 A.M. of the 21st December the battering in breach commenced, and continued for two days. At length, on the 23d, when a practicable breach had been formed, and Marshal Gerard was about to deliver the assault, the garrison surrendered, after as gallant a defence as any recorded in military history, though more remarkable for its passive than its active character. When Marshal Gerard, accompanied by the French princes, entered the fortress, they found General Chassé in a casement in the Alba bastion, which he had occupied during the siege. On their progress from the gate to the governor's quarters, they passed through a scene of desolation and ruin, intermixed with painful and disgusting objects, which baffles all description. The whole, indeed, presented an unparalleled chaos of black

and smouldering destruction; and, with the exception of the principal powder magazine, two or three service magazines, and the hospital, not a building was standing. The terrepleins of the bastions were ploughed into deep ruts by the shells; the gorges were encumbered with heaps of fallen rubbish; and though the casemates and subterranean communications were not perforated, all of them had sustained damage from the incessant explosion of shells, and they emitted an offensive, nay, almost insupportable odour, caused by the number of men who had been crowded into these vaults. Everything was of course said by the victors to console and flatter the vanquished. When Count Gerard took his leave of General Chassé, he observed to the brave veteran, "that it was high time to surrender; that he had gallantly and honourably done his duty, and that he ought not to have held out a day longer." With a fortress reduced to a heap of ruins, a garrison exhausted and extenuated, and a breach sufficiently wide to admit a column formed upon a front of a hundred, it would not have been bravery, but madness, to attempt, under such circumstances, to stand an assault.

The following is a list of the different batteries, with the direction of their fire respectively:—

	No. of Batteries.	24 Pounders.	16 Pounders.	8-inch Howitzers.	10-inch Mortars.	Distance in Yards.	Direction of Fire.
	1	6	...	2	...	535 & 550	Battering the left face of Toledo, and gorge of St Laurent.
Opened on the 4th and 5th December.	2	...	2	2	...	500	Ricochetting the left face of Toledo.
	3	4	...	2	...	640	Battering the left face of the Ravelin.
	4	...	3	2	...	650	Ricochetting left face of the Ravelin.
	5	6	2	1	...	630 & 430	Battering right face of Toledo, and Ricochetting left of Toledo.
	6	...	2	2	...	700	Ricochetting left face of Toledo.
	7	6	2	1	...	380 & 700	Ricochetting left face of St Laurent, and battering right face of Paciotto.
	8	...	3	2	...	465	Ricochetting left face of Ravelin.
	9	...	...	6	...	820	Battering salient angle of Paciotto.
	10	8	...	...	...	650 & 520	Battering left face of Ravelin, and Lunette of Kiel.
	A	...	...	...	10	850	Not armed.
	B	...	...	...	9	1000	Body of the Citadel.
	C	...	...	...	11	1050	....
	D	...	...	...	10	850	....
	...	30	14	20	40	......	....
Between the 8th and 18th.	11	4	...	...	...	500	Battering the right face of Toledo.
	12	...	3	...	...	435	Battering the Batardeau.
	13	...	4	...	...	220 & 275	Battering the left face of Ravelin.
	E	...	...	...	6	500	The body of the Citadel.
	F	...	...	...	6	490	....
	G	...	...	...	6	650	....
	H	...	...	...	6	380	....
	K	...	...	...	8	600	....
	14	6	...	...	..	50	Breaching Battery.
	15	6	...	...	...	350	Counter-battery against the left flank of Fernando.
	16	...	...	...	...	125	Six pierriers on the Ravelin and Toledo.
	L	...	...	...	10	250	Terreplein and rampart of Toledo.

This operation, so instructive in a military point of view, is also remarkable as having occurred in a time of general peace. It would be out of place here to enter into any detail of the complicated series of events and negotiations out of which so singular an occurrence arose: we shall therefore content ourselves with observing, generally, that Great Britain and France, as joint guarantees for the integrity and independence of Belgium, having failed in every attempt to procure the evacuation of Antwerp by means of negotiation, were obliged, by the faith of treaties, to have recourse to force. Hence the siege, politically considered, is to be viewed merely as an ejectment executed against the king of Holland, who had refused to renounce possession, unless compelled to do so.[1]

The French brought against this place 66,450 men, 14,300 horses, and 222 guns of all descriptions; and they lost during the siege 108 killed and 695 wounded, total put *hors de combat* 803. The Dutch had 4937 men in the garrison, of whom they lost 122 killed, 369 wounded, and 70 missing, total 561.

A careful comparison of the details of this siege with the general principles which have been enunciated will enable the reader to recognise the importance of the following maxims.

1. Independently of the great amount of labour to be provided for in the construction of parallels, approaches, and batteries, there will be a daily drain upon the besieger's forces by casualties, so that he can scarcely expect for success unless his original preponderance in numbers has been such as to leave him at the final moment of assault in a condition to attack the diminished garrison with an overwhelming force. In addition, therefore, to a covering army when external relief is threatened or anticipated, the besieging army should be from four to five times the strength of the garrison, or even more, should the nature of the ground, as at Sebastopol, add to the ordinary difficulties of approach. This superiority of force is necessary to give celerity and steadiness to the operations, which would otherwise be tedious and interrupted.

2. A perfect investment is not merely expedient but indispensable. So long as any portion of the enceinte of a fortress is left open or unwatched, the garrison is able to recruit its strength from without, whilst within it is relieved from that moral depression which must, more or less, oppress men when entirely closed up within a narrow space, and exposed, day after day, to fatigue and danger. Under such circumstances there seems to be no natural limit to the power of defence, as fresh supplies of men enable the besieger to go on adding intrenchment within intrenchment, and it is only possible to overcome him by determined, reiterated, and overwhelming assaults. Such *have been* the circumstances of Sebastopol, as the system of attack adopted by the allies has never enabled them to isolate even the southern section of the fortress, the means of communication between the south and north remaining available to this day. Without doubt fresh troops, or rather reliefs, are brought to the south side frequently, and a temporary superiority in numbers on that side given to the defenders over the immediately attacking force. It ought not, therefore, to be a matter of surprise that the progress of the siege is slow, and, to the eye of the general observer, uncertain, because so frequently interrupted.

3. Good and secure lines of communication are most essential, as there ought not to be any cause of interruption when once the ground has been broken and the siege commenced. Neither in the attack nor in the defence should guns be fired idly, or from distances and positions which would render their fire useless; but when the proper distance has been arrived at, battery should succeed battery as the works of approach advance, and no interval for rest or for repairing injuries should be allowed to the besiegers; but how can this object be ensured with roads so heavy and bad as to stop the transport of ammunition and of ordnance?

4. The importance of advanced works was strongly exhibited at the siege of Antwerp, as the whole force of the attack was directed against the advanced lunette St Lau-

[1] The account of the siege given above is abridged from that published in the *United Service Journal*, and which is decidedly the best that has yet appeared.

rent, whilst the defence was good, although under the disadvantage of wanting the collateral defence of the Lunette Montebello (see Plate CCLXII.) In such a case as Sebastopol, the garrison being in fact a small army, such works must afford the best means of an obstinate defence, and, by forcing the besieger to act on the circumference of a larger circle, diminish very much his ordinary advantage of concentration.

Siege of Dantzic.

Having thus given an example of an interior and passive defence, we shall now, in further illustration of the principles already laid down, advert to one of a different if not opposite kind. The siege of Dantzic, whether considered with reference to the magnitude of the operation, the difficulties to be surmounted by the besiegers, or the active and varied character of the defence, was certainly one of the most memorable events in the campaign of 1807. Before the war of 1806 and 1807 the fortifications had been much neglected, because, from the position of the place, no one suspected that it would have to sustain a siege. But when the battles of Iena and Auerstadt had entailed destruction on the Prussian army, and laid open the kingdom, General Manstein, who commanded at Dantzic in the absence of Field-marshal Kalkreuth, the titular governor, had laboured with much activity in improving the exterior works, and particularly in causing them to be strongly pallisaded. It is necessary, therefore, to describe the principal defences at the period when the place was invested by Marshal Lefebvre, at the head of the tenth corps of the grand army, and immediately before the commencement of the trenches on the 1st of April 1807.

The city of Dantzic, traversed by the Moltau, was surrounded with large ditches filled by that river, the waters of which, retained by several sluices, formed, to the eastward, a vast inundation, which, reaching on one side to the suburbs of Ohra and St Halbrecht, and on the other to the dykes of the Vistula, extended about four leagues, and covered two-thirds of the eastern fronts. On the north the Vistula runs about 260 yards from the covered-way, leaving a space between the left bank and the glacis of the place, consisting of an impracticable marsh, intersected by some canals; and at its embouchure, distant nearly three miles, the banks were defended on the right by the fort of Weichsemlunde, and on the left by an intrenched camp in the small island of Neufahrwasser, intended to cover and protect the arrival of such succours as might come from the seaward. The ground adjoining the banks of the Vistula being intersected by canals and covered with marshes, was extremely unfavourable to a besieger, as it rendered it difficult for him to form establishments or raise works of proper solidity, and forced him to extend his quarters, disseminate his troops, and multiply his posts. At the period in question this inconvenience was the more severely felt, because the besieging force was inferior in numbers to that of the garrison, and it required the most vigilant caution to occupy numerous posts without unduly weakening it. The communication between the place and the fort of Weichselmunde was maintained by a series of redoubts constructed on the borders of the Vistula, and particularly by the advantageous position of the isle of Holm, which enabled the besieged so to approximate the fire of the place to that of the fort as only to leave between them an interval of about 1400 yards, and also to communicate with Weichselmunde by the canal of Laack, in spite of batteries which the besiegers might establish at Schellmühl. The French, therefore, could not attempt to throw a bridge over this part of the Vistula until they had made themselves masters of the isle of Holm. On the west two chains of hills, separated by the valley of Schidlitz, covered this part of the enceintc; and the prolongations of these hills were crowned by two forts, that of Bischopsberg and that of Hagelsberg, which, being connected by continuous intrenchments, formed a second enceinte, flanked upon one side by the inundation of the Moltau, and upon the other by the left bank of the Vistula. This new enceinte, though constructed of earth, and without revêtement, was nevertheless secure against insult; and as the covered-way, as well as the foot of the scarps and counterscarps, bristled with strong fraises, which served instead of revêtements, the besiegers had no hope of succeeding by a coup-de-main, and were therefore obliged to proceed by a regular attack. How analogous was this condition of the lines of defence to that of southern Sebastopol after the besiegers had allowed the garrison to recover from their first alarm, and under the guidance of able engineers to place their old works in order, and to supply their deficiencies by new works.

From this description of the defences ot Dantzic, it is easy to perceive that the difficulties attending the operation must have been very great. The principal of these, as stated by General Kirgener,[1] who, until the arrival of General Chasseloup, directed the attack, were, 1st, that Marshal Lefebvre had at first an army inferior to that of Marshal Kalkreuth, and that this army was in a great measure composed of new troops, all those destined for the siege not having then arrived; 2dly, that, owing to the badness of the roads and the inclemency of the season, the artillery experienced the greatest difficulty in bringing up its convoys, whilst the establishment of the batteries was retarded, and a scarcity of ammunition sometimes prevailed; 3dly, that the place requiring an immense circumvallation, which, in fact, could not be completed until after the arrival of reinforcements, the corps of troops which occupied the quarters were extremely weak, and hence could neither furnish a sufficient number of workmen at a time, nor even the number of men necessary for guarding the trenches; and, 4thly, that the besiegers had no good plan of the place, no idea of the depth of the ditches, and that, as the accidents of ground in front of the fortifications were extremely diversified, they could only be reconnoitred in proportion as the works advanced. These circumstances, all of which were reproduced at Sebastopol, the necessity of concentrating the greater part of the troops close to the camp of Neufahrwasser, by which succours arriving by sea might debouch, and, lastly, the advantage which the besieged had been able to preserve of remaining masters of part of the suburbs, determined the chief engineer, after the investment had been effected, to direct the principal attack against the Hagelsberg, and a false one against the Bischopsberg fort. The true point of attack was the long branch of lines in the plain connected with the bastion on the right of the Hagelsberg: "c'était là le défaut de la cuirasse;" but, for the reasons above stated, General Kirgener was induced to direct his approaches against the fort itself.

As the details of this great siege would fill a considerable volume, all that our limits permit us to attempt is merely to indicate the principal occurrences. On the 1st of February 1807 the troops of General Dombrowski began to approach Dantzic, and took up a position at Mewe, upon the left bank of the Vistula. On the 15th General Ménard, commanding the Baden contingent, arrived at the same point, and repulsed a detachment of the garrison of Dantzic, which had advanced from Dirschau to attack him. On the 23d General Dombrowski, having been reinforced,

[1] This officer, the head of the engineer staff, and one of the most distinguished in that branch of the service, fell on the field of battle at Bautzen, where he received his death-wound from the same ball which killed Duroc, the grand marshal of the palace, and the intimate friend of Napoleon.

received orders to attack a large detachment of the enemy which occupied an advantageous position at Dirschau and its environs. The combat here was obstinate and sanguinary; but the Prussians, though intrenched in a church and a churchyard, were dislodged and driven back, chiefly by the Poles, who, exasperated by their long resistance, put to death without mercy all who fell into their hands. After the combat of Dirschau, General Manstein no longer sought to obstruct the distant approaches. The troops destined to form the besieging army now arrived in succession, and the park of artillery began to be formed. On the 12th of March Marshall Lefebvre found himself in a condition to close in on the place; and the troops of the garrison having withdrawn, he distributed his own in the following positions: A battalion of French light infantry at Ohra, a Saxon battalion at St Halbrecht in the Burgerfeld, and two others at Tiefensee and Kemlade; the Poles occupied Schonfeld, Kowald, and Zunkendin; some battalions took post at Wonnenberg, Neukau, Schudelkau, and Sniekau; the Saxon cuirassiers and light horse were stationed at St Halbrecht and Guirsehkens; the 19th regiment of French chasseurs at Burgfeld, and the 23d at Schudelkau; the Baden dragoons and hussars at Wonnenberg, and the Polish lancers at Langenfurt. On the 16th the marshal attacked the village of Stolzenberg, which he carried after a warm resistance, as he did also the suburb of Schidlitz, to which the Prussians had retired; and on the 18th the place was entirely invested, with the exception of the eastern part, which, by the isle of Nehrung, communicated with Königsberg. Field-marshal Kalkreuth now arrived in Dantzic, and assumed the command of the place. The next operation of the besiegers was the attack of the isle of Nehrung, which, after a severe and protracted struggle, was carried in the most gallant manner, and measures immediately taken to secure possession of this important conquest. A bridge was also established on the Vistula, and various works constructed to check the attempts of the enemy either on the side of Dantzic or on that of Pillau. At this time the governor, who, besides the burgher militia, had under his command a garrison of 18,000 men, made a sortie for the purpose of destroying the works already commenced by the besiegers; but the attempt failed, and the Prussian columns were compelled to retreat into the place without having obtained the smallest success upon any point.

As it had been decided that the principal attack should be directed against the fort of Hagelsberg, favoured by two false attacks, the one directed against the intrenched camp at Neufahrwasser, and the other against Bischopsberg, and also by two other secondary attacks on the left bank of the river, ground was broken on the night of the 1st and 2d April, at the distance of 1600 yards from the pallisades. The approaches were pushed forward with the greatest vigour, and on the night of the 11th the second parallel was commenced by means of the flying sap. On the morning of the 12th the marshal ordered the batteries to be armed, which was accordingly done. On the 13th the enemy made a sortie in force, attacked the Saxons with great impetuosity, carried a redoubt constructed upon the mamelon of Hagelsberg, and even penetrated to the head of the trenches; but they were ultimately repulsed, though not without difficulty and loss. By the 23d all the batteries of the first and second parallels, and those of Stolzenberg, were armed, and emplacements were provided for field howitzers, in order to throw shells into all quarters of the city. At daybreak on the 24th the batteries were unmasked, and though the garrison returned the fire with the greatest vivacity, that of the besiegers soon obtained the ascendancy, committing great ravages in the place. Being apprised of this circumstance, Marshal Lefebvre summoned the governor, who replied in a manner worthy of himself. The fire of the mortar and reverse batteries continued during the 25th, in the course of which a new battery was constructed between the low flanks of the Stolzenberg; and the direction of some others changed, in order to batter the right bastion of Bischopsberg, the fire of which had greatly incommoded the French batteries. During the day of the 26th, the fire on both sides was exceedingly animated; but at seven in the evening, that of the garrison suddenly ceased, and a column of 600 Prussian grenadiers, followed by 200 workmen, soon afterwards sallied out of the place. As the sortie had been foreseen, however, preparations were made to repulse it, which was done by a combined attack in front and on both flanks, in consequence of which the whole column was either killed or taken. Meanwhile the works were vigorously pushed forward at all points. The batteries of Stolzenberg were united with the attack on the Bischopsberg; emplacements were prepared for batteries *à ricochet;* at the attack of the Lower Vistula the works were continued, and a tongue of land situated at the extremity of the isle of Holm taken possession of and isolated by means of a cut; whilst at the principal attack the greatest exertions were made to prolong the right of the third parallel, and enlarge the communications. On the 30th April the batteries of the besiegers, augmented by several pieces which had arrived from Warsaw, thundered on the place, in different quarters of which conflagrations now appeared; and the besieged replied by the fire of all the batteries of the front of the attack, directing more than thirty pieces on a redoubt which fired with the greatest effect. But as the fire of the besiegers had made little impression on the exterior fortifications, which were of earth, it was during the first days of May directed chiefly against the palisades, in order to facilitate the assault of the place; and the utmost activity was at the same time evinced in extending, improving, and urging forward the attack; whilst, on the other hand, the garrison showed equal vigour in obstructing the approaches and destroying the works of the besiegers. In fact, notwithstanding the address of the French artillery, that of the garrison still remained effective, because it had not been possible to ricochet the lines of the fortifications, and the resources of the besieged in munitions of all kinds were more considerable than those of the besiegers. In the whole of these circumstances may be seen a rehearsal, as it were, of those of Sebastopol; and the reader will, after a perusal of this description, cease to imagine that the Russians had acquired their knowledge of the use and importance of earth-works from the writings of any author of our day. At Dantzic, as at Sebastopol, a powerful army, guided by a skilful engineer, was enabled to apply the resources of parapet fortification so effectually in defence as to baffle for a long time the efforts of the besiegers.

On the urgent recommendation of General Chasseloup, who had by this time assumed the direction of the attack, it was now decided that the isle of Holm should be assaulted, as the possession of it would enable the besiegers to construct new batteries, to take in reverse the front of the attack. The besieged had spared no pains for the preservation of this important post. In the night of the 6th and 7th of May, however, it was attacked, and, after a desperate resistance, carried; whilst the possession of it was secured by works added to the intrenchments which had just been stormed, and the batteries were turned against the place. At the principal attack the fire of the besiegers had also mastered that of the besieged; and Marshal Lefebvre was preparing to assault the fort of Hagelsberg, when a Russian corps d'armée under the command of General Kamenskoi arrived by sea, and disembarked at the intrenched camp of Neufahrwasser.

At the moment of landing his troops, General Kamenskoi was ignorant of the capture of the isle of Holm, and he was disconcerted to find such an obstacle to his communications with the place. This occasioned delay, which

Fortification.

proved fatal to his enterprise; for had he attacked immediately on landing, it is not improbable that he would have succeeded. It was only on the 15th of May, however, being the fourth day after the disembarkation, that he resolved to make an attempt to succour the besieged city. He began to debouch at four in the morning, and, under cover of a brisk cannonade, formed his force, consisting of from 11,000 to 12,000 men, in four columns of attack. The onset was impetuous, and at first the Russians gained ground, thrice attempting to penetrate the French line; but they were ultimately repulsed at all points, and forced to retreat with great loss to the intrenched camp. Field-marshal Kalkreuth made no attempt to second this attack by means of a general sortie, which would have placed the French between two fires; and by its failure the fate of Dantzic was decided. Such was the issue of the only effort made by the allies to relieve this important fortress.

The works of the besiegers were now pushed forward with redoubled vigour; and in the course of the following day preparations were made for the assault of Hagelsberg. Foreseeing this, Marshal Kalkreuth resolved to make a last effort to destroy the nearest works of the besiegers, and for this purpose ordered a grand sortie, which took place on the evening of the 20th May; but although the Prussians fought with all the fury of despair, they were at length driven back, and pursued even into the ditch of the place. On the 21st the army of siege was reinforced by the arrival of the troops of Marshal Mortier, part of which had remained before Colberg; the marshal himself quickly followed; and orders were immediately issued for the assault of Hagelsberg. Before giving the signal, however, Marshal Lefebvre again summoned the governor of Dantzic, who, having no longer any hope of being succoured, and convinced that the besiegers were in a condition to make themselves masters of the fort of Hagelsberg, showed a disposition to capitulate. A suspension of arms was accordingly agreed to, and this was followed, on the 24th of May, by a capitulation, the principal conditions of which were similar to those which the field-marshal himself had granted to the garrison of Mayence in 1793.[1]

The preceding narrative will in so many respects appear to be an anticipation of the defence of Sebastopol, that it may be well to remark that such as the two defences have been in their beginning and progress so may it be expected that the two sieges will be in their termination—namely, successful for the besiegers. The Prussians and the Russians did everything which bravery and skill could do to save Dantzic, making at the last a bold and gallant attempt to raise the siege by a general attack. Already the Russians have made several grand sorties, and two general attacks of no ordinary magnitude and importance, and it may be expected that before winter they will again endeavour to force the position of the allies; but should they fail, and can it be doubted that they will, how can the Emperor of Russia expect to keep longer from their grasp the just reward of gallantry and perseverance, almost beyond example, for which they have been contending! The hope of the Russians can now only be formed on success in the field, and as that hope becomes with each successive attempt and failure less bright, so must the gloom of disappointment and despair darken until the end shall come, and Sebastopol, although perhaps in ruins, be abandoned to its fate.

BASTIONED SYSTEMS OF THE NETHERLANDS.

The bastioned system of the Italians was soon carried into other countries by their engineers, who were extensively engaged in the service of foreign princes, and it was thus that the celebrated Italian engineer Marchi, coming to Brussels with Margaret of Austria in 1559, appears to have introduced the bastioned system into the Netherlands. It has been shown that in rampart defences, the ordinary earthen scarp adopted in ditches of parapet works had been replaced by a masonry revêtement as a security against surprise, in consequence of which, in old Italian fortresses, lofty revêtements were almost universal; but in a country the soil of which was permeated by water within a few feet of the surface, such a mode of guarding against escalade would have been enormously expensive, and in consequence advantage was taken of the nature of the country to form broad wet ditches round the ramparts, and thus, by securing them from any sudden attack, to render the revêtement unnecessary. The first example of a fortress surrounded by simple earthen ramparts without revêtements is said to be that of Breda, fortified in 1553 by Count Henry of Nassau, and this arrangement required only to be moulded into the bastioned trace to constitute the ancient system of the Netherlands, as described by Freitag in 1630. Freitag made the flanks of his bastions perpendicular to the curtain, the faces 98 yards long, with a flanked angle not exceeding 90°, and the length of the curtain 149 yards.

Freitag had strange notions respecting his profiles, regulating the height and thickness of his ramparts not so much by the resistance they were required to make against artillery as by the *number of sides* of his polygon; but disregarding these vagaries of the systematist, the annexed cut, fig. 40, may be assumed to represent the profile usually adopted by the Dutch engineers, R being the body of the place, F the fausse-braye, D the ditch.

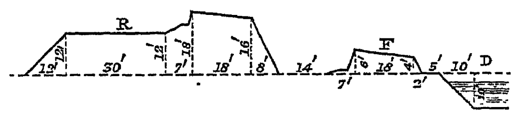

Fig. 40.

It will be observed from the profile, that the main rampart is surrounded by an advanced parapet called a fausse-braye, a work to which reference has been made in a preceding page. By this parapet it was intended to obtain a grazing fire on the ditch, whilst the space between it and the rampart formed a spacious *chemin des rondes* well fitted for the assemblage and movement of troops for defensive purposes; but great as these advantages are, the fausse-braye has dropped into disuse, as it was found scarcely possible to remain in it under a heavy vertical fire, the shells either dropping directly, or rolling down into it from the superior slope of the rampart above. Such *shell traps*, as they are called, are scrupulously avoided by modern engineers, who well know that the improvement of vertical fire will ere long add materially to the difficulties of defence. In the recent bombardment of Sweaborg, a tolerable illustration has been afforded of what may be done by heavy mortars, when the shell has been made a better representative of a mine than it now is. At present a 13-inch shell weighs, when loaded, 200 pounds, and may carry with it, when filled, a charge of 11 lb. of powder, which is ample for breaking the shell and scattering its fragments, but is insufficient for producing great effects as a mine. Should however the projects of Nasmyth and of Mallett be carried into effect, and there can be little doubt that in a modified shape and degree they will, the shell becoming a mine will

[1] Dumas, *Précis des Evenemens Militaires,* tom. xviii., chap. 19, p. 123. *Relation authentique du Siege de Dantzick.* "Les principales conditions de la capitulation furent que la garnison sortirait avec armes et bagages, drapeaux déployés, tambour battant, mèche allumée, avec deux pièces d'artillerie legère et leur caissons attelés de six chevaux, pour être conduite aux avant-postes de l'armée Prussienne à Pillau, en passant par l'île de Nehrung, et en cinq jours de marche. Cette garnison s'engageait à ne pas servir contre l'armée Française pendant un an." (Dumas, *ubi supra.*)

carry with it 1, 2, or 3 cwt. of powder, to destroy not only buildings, but also earthen parapets and ramparts. Passing from the ancient Dutch system as described by Freitag, Marolois, and others, the modern or improved Dutch system of Coehorn deserves especial attention, and is represented in Plate CCLXI., fig. 1, which exhibits his first system.

The great characteristic in this system is the combination of wet and dry ditches, and the use of covering works, or couvre-faces, intended to preserve the body of the place from injury till an advanced period of the siege. These envelopes were first proposed by Dürer, and in like manner the remarkable orillon of Coehorn is a reproduction on a moderate scale of the complicated masonry, or casemated structure of one of his basteien. Coehorn was also well acquainted with the principles enunciated, and the systems proposed by the truly eminent German engineer Speckle, and has manifestly adopted them when applicable to his purpose. The profile, fig. 41, will best enable the student to appreciate the difference between the dry ditches of

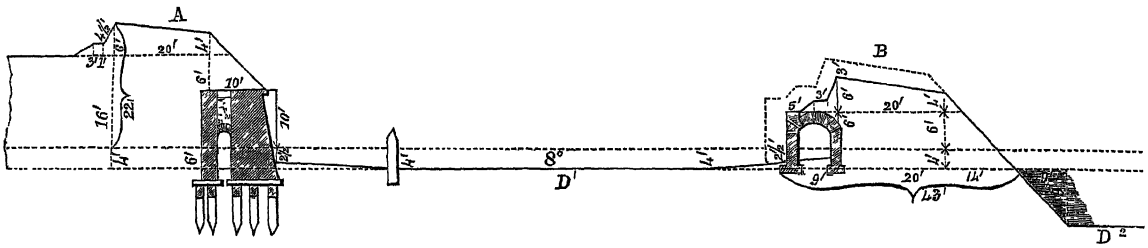

Fig. 41.

Coehorn and the narrow passage afforded by the fausse-braye of the older engineers. A, inner or upper bastion; B, outer or lower bastion; D¹, dry ditch betwixt the two; D², wet ditch.

The profile also exhibits the loop-holed galleries of the counterscarp, by which a reverse musquetry fire may be obtained on the revêted scarp of the inner rampart; a system of defence which has since been very generally adopted, and is most valuable when a secure communication can be kept up between the galleries and the work which they are intended to defend. After the great siege of Corfu by the Turks, and its successful defence by Schullemburg, some Dutch engineers who had been invited to Corfu by him, and had taken part in the defence, were employed in adding detached forts to the old Italian bastioned fronts. In these works, now partly in ruins and partly destroyed, numerous examples of loop-holed galleries and loop-holed traverses may be observed, and they serve to demonstrate, that though Coehorn adopted in his systematic writings his reliefs to the aquatic sites of Holland, he developed principles and means of defence which were equally applicable to other sites and other countries. It has been argued by Bousmard and others, that an opening would be formed by shells through the couvre-face; and that the flanks of the bastions would be thereby exposed to the fire of the counter batteries on the glacis; but it remains yet to be proved whether such an opening through an earthen mass as is here assumed to be made by the horizontal firing of shells could really be thus effected; and the French translator of Zastrow, M. Neuens, captain of artillery, justly remarks, "that if shells fired horizontally into earthen works are so efficacious in destroying them, such shells must be a still more powerful instrument in the hands of the defenders for destroying the besiegers' batteries." If indeed, Zastrow himself observes, we admit with Coehorn and others, that though the besieger may succeed in destroying a few feet of the parapet of the lower or outer face of the bastion, he would in vain by firing horizontal shells into its mass endeavour to lay open the counterscarp galleries, it must be admitted that the besieger on mounting the low face would find himself in a most critical position, as all the defences, both direct and reverse, of the dry ditch, would remain uninjured, and be in full action against him. These dry or inner ditches, as greatly facilitating the war of sorties, and the reverse or counterscarp galleries, are defensive arrangements of great merit, and may, by fitting modification of profile, be adapted to any site; though, of course, the advantage possessed by the dry ditches in such countries as Holland, of not allowing the besieger to excavate in them without coming to water, cannot be expected in other sites, and must be made up for by stone pavements, or other contrivances likely to embarrass the besieger in his excavation. Coehorn assumes the plane of site to be only 4 feet above the level of the water, and the dry ditch of his bastion is at its centre just on the level of the water, so that a passage by sap becomes impossible, as the spade sinks at once into water; but near the scarp and counterscarp the ditches only sink $2\frac{1}{2}$ feet, sloping on each side towards the central portion. The breadth of the dry ditch of the bastion is 98 feet, and that of the wet ditch before the salient 148 feet. All the slopes are at an angle of 45°. The whole breadth or thickness of the couvre-face, measured at the water level, is 52 feet, so as not to allow room for the besiegers' batteries; and its relief of construction only $12\frac{1}{4}$. Ravelin, relief of low face 10 feet, of high face $18\frac{1}{4}$, and the height of its revêtement 8 feet; here also the thickness of the low face would not afford space for forming batteries. The width of the dry ditch is the same as that of the bastion. These few details, together with an examination of the Plate CCLXI., and of the woodcut 41, will enable the student to comprehend the general principles of this great engineer, and it is rather by tracing out the several ideas of a master mind, as exhibited in the *peculiarities* of his plans, than by studying the plans themselves as wholes, that the younger engineer will acquire that store of practical knowledge which will enable him to vary his own projects, so that they may really be the best suited for the ground he is working upon.

Coehorn himself exemplified the observations which have been here made, as he never restricted himself to the rules even of his own system. In fortifying Gröningen he was required to construct works on an eminence which commanded the town, and he adopted a trace which, towards the exterior, exhibited a series of tenailles, the gorges of which were closed by small bastioned fronts constructed of walls which should be easily breached from the main works when the enemy had succeeded in gaining possession of any one of the intervening redans. By this curious combination of the tenaille and bastioned systems, Coehorn gave an undoubted proof of his superiority to the narrow prejudices which prevent many men from adopting the system best suited for the particular place. His example should be followed by every sensible engineer.

BOUSMARD, CARNOT, CHASSELOUP, DUFOUR, HAXO, CHOUMARA.

It would be wrong to dismiss the subject of bastioned systems without at least some more reference to the works of

these distinguished engineers than has been given in tracing the history of this subject. Bousmard makes the faces of his bastions as well as their flanks curvilinear, the former convex, and the latter concave outwards; but though from this arrangement the effect of ricochet fire may be diminished, the difficulty of effectually defending the salient from the flanks is much increased. His great innovation, however, consisted in placing the ravelin and its redoubt in *advance* of the glacis of the body of the place, and forming in front of them a second or advanced covered-way; the object of the arrangement being to close the main ditch entirely, so that the batteries should not fire upon the body of the place through the ditch of the ravelin. The covered-way is made *en cremaillière*, and at each bend there is a sort of redoubt, or casemated traverse, not a simple hollow traverse loop-holed, such as those in the detached works of Corfu. It has been objected to Bousmard's system that his advanced works would be speedily taken by turning the gorges both of the ravelin and its redoubt, but it should be remembered that the interior slope of both is replaced by a loop-holed wall, being the front of an arched gallery running all round, so that the enemy could not remain within exposed to the fire from the galleries, as well as to that from the body of the place. Without advocating the precise form and disposition of the works recommended by Bousmard, it may be reasonably asserted that in every case of a powerful and well appointed garrison the defence will gain by assuming an active character beyond the precincts of the glacis.

It has been already observed that an unmerited indifference has been manifested by many engineers to the merits of Carnot, principally, it may be believed, from his exaggerated estimate of the effects of a vertical fire of small projectiles. Notwithstanding, however, his appeal to imagination rather than to calculation, when he assumed that by substituting 600 wrought iron balls, weighing each $\frac{1}{4}$ lb., for the one shell of 150 lb. he might expect with 6 mortars to project 3600 balls, and to put *hors de combat* 20 men at each discharge, or in 100 discharges 2000, he was right in urging the importance of vertical fire. Carnot, born in 1753, was at an early age a member of the Corps of Engineers, and for his mathematical works elected a member of several learned societies. At the Revolution he was a member of the constituent Assembly; he voted for the death of the king, distinguished himself in the army of the North, and when a member of the committee of public safety, directed in great measure the movements of the French army. In 1795 he was named minister of war, but quickly expelled by Barras and exiled the country; but being recalled, was again, in 1799, appointed minister of war. In 1802 he retired from office, and with that stern integrity which marked his character and made it resemble so much the noble independence of Arago, he voted against the elevation of Napoleon to the imperial dignity. Napoleon did not allow this rigid adherence to principle to disqualify the patriot for employment, and charged him with the defence of Antwerp, as he at a later day named him a peer of France, and confided to him the office of minister of the interior. After the fall of Napoleon he became a member of the provisional government, and was immediately afterwards banished from France. He died at Magdeburg in 1823.

Carnot constructed his scarp without a revêtement but placed a detached loop-holed wall in front of it with a chemin des rondes between, which is one essential feature of his system, the wall being constructed with arched niches in rear so as to shelter the men defending it; the loop-holes are in two rows. He provided arched casemates for mortars on the gorge of his bastion in order to fire upon the capital, and the loop-holed wall of an inner curtain being continued along the retired flanks and in front of these mortar casemates, formed a complete inner retrenchment. Between the tenaille and the ravelin was an elevated earthen cavalier, occupying the position of a redoubt in the ravelin, before the bastion's counterguard; so that the whole of the interior works were masked by these earthen envelopes. There is much ingenuity in these arrangements, and at least as full an appreciation of the value of earthen works as can be found in the writings of any modern writer. Carnot's leading principle however was, that a successful defence must depend on the active operations of the garrison, and that sorties therefore should be frequent and determined as soon as the enemy had approached close to the fortress. For this purpose he removed the revêtement from the counterscarp, and formed it into an easy, or countersloping, glacis to admit of the ready advance of the troops from the ditch upon the head of the besiegers' sap. He supposed that the overwhelming vertical fire of the 10 mortars in the mortar batteries in the gorges of his bastions would prevent the enemy from accumulating large covering parties in the trenches, and that he should therefore be able to fall upon the working parties and successfully delay the progress of the works. It has been shown that Carnot entertained an exaggerated view of the effects to be produced by a peculiar description of vertical fire, but the idea of securing his mortars in casemated buildings is good and has been adopted in one part of the citadel of Ghent; and it is impossible to study his works without being benefited by them. Chasseloup was born in 1754, and died in 1835. He was a lieut.-general, and under Napoleon, Lieut.-General of engineers. Like Bousmard he placed his ravelin in advance of the glacis, and provided it with a small casemated keep, the flanks of which are pierced for two guns each. The tenaille is also provided with casemated flanks, and in front of it is a casemated redoubt or bastionette to supply the place of the ordinary ravelin, and to flank the salient portion of the face of the bastion, the general face being by him bent into two so as to place the salient portion in line with the exterior side of the polygon and thereby secure it from the ricochet fire. Casemated redoubts in the re-entering and salient places of arms, a defensive barrack, and a permanent entrenchment on the bastion are also included in his arrangements. De Sellon (*Memorial de L'Ingénieur Militaire*) observes, "It would indeed be well to force the besieger to pass through two sieges, if the outworks, pushed so far forward, had higher scarps, and were not so easily turned at the gorge; but as the scarp is only 13 feet high, this possibility of attacking the works by the gorge without a previous descent into the ditch, presents such serious inconveniences that it is surprising to observe that Bousmard and Chasseloup should have adopted so defective an arrangement." But notwithstanding this strong condemnation, it is at least doubtful whether such works are not the most suitable for a vigorous defence by a strong garrison, as they would enable the besieged to fall upon the assailants at the most critical moment of their attack with a powerful force; and further, it may be added, that a skilful engineer would know how to throw many difficulties in the way of turning these advanced works, whilst the continuance of the besiegers in them might be rendered both difficult and dangerous in the extreme.

Dufour.

The most remarkable feature in Dufour's modification of the modern system is, that one face of the redoubt in the re-entering place of arms is carried across the ditch, and connected with the coupure of the ravelin, so as completely to close the ditch and cover the face of the bastion from the fire of a battery on the glacis of the salient of the ravelin. Dufour also raised the salient of the ravelin into a high cavalier, so as to secure the faces from ricochet; and he proposes that the cavalier shall be formed of gravel or small stones, so that the fire from the body of the place may cause the enemy, when he has in part destroyed it, and is

Fortification.

attempting to form a lodgment, great damage by scattering about these natural missiles.

Noizet.

General Noizet has been already mentioned in connection with the modern system, his modification of which is now the normal system adopted at all the French military schools. Not adopting Dufour's mode of closing the ditch of the ravelin by carrying across it one face of the redoubt of the re-entering place of arms, he effected this object by placing a massive mask between the coupure of the ravelin and the re-entering place of arms, from the inner scarp of which it is separated by a passage. The counterscarp of the bastion is carried continuously along the inner edge of the mask, whilst in front of it is a ditch which separates it from a demi-caponnière forming its counterscarp and covered-way, and a glacis sloping down the ravelin of the ditch. The mask, the lunette redoubt in the ravelin, and the redoubt in the re-entering place of arms, form a combined series of works of great efficiency for defence, and which completely cover all but the salient portion of the face of the bastion. The flank of the bastion, as before observed, forms an angle of 80° with the line of defence, and the advantage taken of this in the citadel of Ghent in forming a most powerful intrenchment in the bastion, with a curtain as long as that of the main front, has also been pointed out.

Haxo.

General Haxo was one of the most able engineers of modern times. Under Napoleon he distinguished himself at the sieges of Lerida, Mequinenza, and Tarragona. On the restoration he was appointed president of the engineer committee, and directed the construction of the fortifications of Belfort, Sedan, Grenoble, and l'Ecluse. He directed the operations of the siege of Antwerp, and died in 1838. Haxo did not publish his scheme of defence, nor did he reproduce it as a whole in the works he constructed; doubtless considering, as has been so frequently urged, that systems, so called, can only be looked upon as the exhibition of great principles, not as a rigid rule for their application. His ravelin is made very prominent, and the salient is formed into a traverse, or mask, casemated and armed with artillery. Within the ravelin there is a redoubt, and within that a casemated caponnière or bastionette. The ditch of the ravelin is closed by continuing the counterscarp across it with a glacis slope into the ravelin ditch, and by this arrangement the ditch of the redoubt in the ravelin is also closed. The counterguards, the higher and the lower bastions, form almost three lines of defence, of which two, the outer and inner, are powerfully armed with artillery. The peculiar characteristic of the system is, that the parapet is thrown back, and made in its trace independent of the scarp, so that, whilst the latter retains the usual straight line, the parapet is broken into several portions not in the same line, and thus secured from the effects of ricochet—an arrangement of very great merit. Haxo is probably better known to English engineers as the inventor of casemated batteries *à l'Haxo* than from his merits as an engineer, great as they manifestly were. These batteries are formed *in* the parapet, and though arched over with masonry are covered with earth. They are open in the rear to the terreplein, and the openings in front for the guns are continued into embrasures formed in an extension of the parapet at these points beyond its ordinary retired position in Haxo's system. These batteries are thus secured from the effects of the enemy's fire, and when the embrasures are masked are equally hidden from his view, so that they may at any moment suddenly open a powerful and unexpected fire upon the besiegers. Being open in the rear, and connected together by arched openings between every pair, the circulation of air is sufficient to do away with the inconvenience from smoke, so generally complained of in casemated batteries. The batteries *à l'Haxo* have been used at Grenoble and Lyons, and in the forts of Loyasse and Sainte-Foy.

Choumara.

The work of the commandant of engineers, M. Choumara, entitled *Memoirs sur la Fortification*, was published in 1847. In this work he maintains the principle, that the direction of the parapet should be independent of that of the scarp, the latter being formed in straight lines, and considered permanent during the siege, whilst the former may be broken into several lines, and may be modified during the siege so as to facilitate the defence in any direction. Haxo had in his lessons or studies pointed out the importance of this principle; but Choumara was the the first to advocate it in print, though it should be observed that the castle of Naples exhibits an early example of the reverse operation, a new scarp having been built in front of the ancient round-tower forts, so as to change them at the *base only* into bastions, whilst the upper portion of the towers became retired and independent parapets. Choumara, not relying on the bent trace of his retired parapet as a security from ricochet, proposed a traverse in the capital of his bastion, placed outside of the retired parapet, and 33 yards in length. This traverse, made 26 feet high and 78 feet wide at its base, would occupy less than two-thirds of the space of the twelve ordinary traverses required to secure from enfilade the faces of Choumara's bastions 164 yards in length, whilst it would cover not only the bastions but also the flanks. In addition, however, to the traverse or mask in the capital, Choumara proposed high traverses, formed parallel to the flanks, at about 22 yards from the salients, which would not only secure the faces from enfilade, but would form secure or interior flanks, as cavalier flanks commanding and firing over those in front. By making the cavalier flanks 98 yards long, and casemating them *à l'Haxo*, 15 guns might be placed in each, and the covered-way of the bastion attacked would be commanded by 30 guns in addition to those of the ordinary flanks, whilst the traverse of the capital would secure the flank cavaliers from ricochet. Any one who reads and studies these simple and yet effective arrangements will not, it is hoped, longer imagine that the importance of earthen works in their proper place had been overlooked by modern engineers, even though they had learnt to value the beautiful and scientific arrangements of their predecessors. The last and most remarkable suggestion of Choumara is another illustration of the same remark, as he proposes to widen his ditch to about 50 yards, and leaving a passage of communication of 16 yards round the base of the scarp, to form an interior glacis, sloping up from the base of the counterscarp towards the summit of the scarp, and having a base of 34 yards wide, thus constituting a continuous mask round the whole escarp. In respect to countermines, Choumara proposes to replace the great galleries, which are usually made 6 feet high and 3 feet wide, and which are, as it were, the great arteries of a system of mines, by large vaulted galleries from 16 to 20 feet wide, pierced through the counterscarp, and continued as far as the third parallel. Six of these galleries were to be formed in each front, being placed about 55 yards apart, and connected together by minor transverse galleries or branches. Galleries of this magnitude would, in time of peace, be useful as stores, and in time of war would greatly facilitate the operations of the miner. The subject of military mining is so extensive in itself, that it must be deferred to a future article on the subject; but it may be here stated, that this subterranean warfare exercises great ingenuity, and requires great skill both on the part of the besieged and the besieger. The besieged has had the advantage of forming the main galleries of his countermines beforehand, but in spite of this a war of mines must generally be in favour of a besieger, since every explosion of the mines of the besieged, however partially destructive it may have proved to the immediate assailants, must destroy some portion of the works of defence, whilst each one of the besieger's mines must operate in favour of the attack alone. Starting,

however, with this principle, that a fortress, except in some situation which renders regular attack impossible, must ultimately fall, the real object of defence is to occupy the enemy for a sufficient time to suit the purposes for which it was constructed, and in this view of the case the destruction of the battery or of the lodgement of a besieger might materially protract the resistance of the intrenchment formed in a bastion, and thus enable the besieger to maintain his ground so much the longer. The most simple form of mine, and that which may be most readily applied as an obstacle in the way of the assailant, is the fougasse. It consists of a chamber placed at the bottom of a simple pit about 12 feet deep, so as to dispense with the labour of forming a gallery. The charge is placed in a wooden box, and both the charge and size of the box may be thus estimated. When the line of least resistance, or shortest line drawn from the centre of the charge to the surface of the earth, which in this case is the depth of the pit, is 10 feet, a charge of 100 lb. will produce an *entonnoir* or excavation, the radius of which is equal to the line of least resistance, and it has been ascertained that the volume of the excavation varies with the charge, the line of resistance and the resisting medium being the same, and that the volume varies also as the cubes of the lines of least resistance; hence, therefore, if W represent the weight of the charge, B the bulk of the *entonnoir* corresponding to 100 lb. of powder and a line of resistance equal to 10 feet, and b that of the entonnoir corresponding to the charge W and the line of least resistance R, we have $100 : W :: B : b$; but as $B : b :: 10^3 : R^3$, we have $100 : W :: 10^3 : R^3$, and $W = \frac{R^3}{10}$. Now let S = side of cubical box to contain the charge—55 lb. of powder thrown loosely in filling one cubic foot, and $S = \sqrt[3]{\frac{R^3}{10 \times 55}} = 0{\cdot}122\ R$, or nearly $\frac{1}{8}$ R in feet. The pits for fougasses vary generally from 8 to 12 feet in depth, and from 3 to 4 feet in width, being made square, and either secured by being revetted with planks or not, as the earth is or is not firm enough to support itself; and for this latter purpose gabions may be used made of different diameters, so that one may be slipped through the others which have been previously fixed. The box for the powder is well tarred, and when intended to be left in the ground for some time, it may be covered with tarred canvas and then put into another box, also tarred both inside and out. The charge is ignited by a saucisson or linen tube about an inch in diameter, filled with powder, and either laid in a wooden case well tarred, or suspended in it. The saucisson and its wooden case, or other covering, whatever it may be, should be sunk some feet in the earth in conveying it from the charge and pit to the place from which it is to be ignited, in order to secure it from accidents as well as from the enemy's observation (see woodcut, fig. 41). In the figure is also represented the mode in which the fire is applied by what may be called the fire-box, the end of the trough and powder-hose being introduced into it. As the object of military mines requires *immediate* explosion, it is manifest that the firing must be effected by some contrivance for producing instantaneous ignition to be really effective, but this may now be done in so many ways independently of voltaic action—by the use, for example, of friction and detonating tubes—that it would be useless to detail them. It is true that experience has shown how little real injury the explosion of fougasses can do to an assailant; but, as the moral effect of the belief of their existence is a certain degree of hesitation or irresolution, often greater than that produced by actual casualties from musketry fire, the mine must still be considered useful to defence as an obstacle in the way of the assailant. Loaded shells packed in a case may be substituted for the ordinary charge, the case being formed with a partition, and the fuses of the shells placed on the lower portion of the case, passing through holes in the partition, so as to be brought into connection with the saucisson or firing-hose in the upper portion of the case. Another form is the stone fougasse, which is probably the most effectual of all. It is constructed thus: a conical pit is made in the earth about 5 or 6 feet deep, the axis being directed towards the enemy at an angle of 45° with the plane of construction, and at the bottom a charge of 50 lb. of powder is placed in a well-tarred box. Over the box, and perpendicularly to the axis of the cone, is fixed a lid, on which as a platform are packed either stones or broken bricks, which, on explosion, are scattered over a space of about 60 by 70 yards. It should be laid down as a rule that means for discharging mines ought to be provided within the fortress, either by using the voltaic battery for the purpose, or by preparing openings in the works through which the powder-hose may be carried.

The last great modification proposed by Choumara is the extension of the exterior side, and this can no longer be a matter of doubtful expediency when the effective range of the rifled musket has become equal to that of smaller ordnance. The length of the line of defence may now be safely and advantageously fixed at 400 yards, so that musketry and artillery may co-operate together efficiently. Chasseloup had, indeed, also proposed to make his exterior side about 700 yards long; and he was not a mere speculative engineer, as he had fortified with great skill under the orders of Napoleon, Alessandria in Piedmont; but it must be borne in mind that no greater distance should be allowed for musketry than is compatible with distinct vision and a correct appreciation of distance, and further, that the men intended to use the rifle in a fortress ought to be well trained for that object, as the loose fire of untrained men would probably be little better with the rifle than with an ordinary musket.

CONCLUSION.—GERMAN SYSTEMS OF DEFENCE.

After having traced the history of bastioned defence to the high state of perfection it has now attained, a brief summary of other systems seems necessary to complete the subject. It has been shown that no sooner had the Italians invented the bastioned system of defence, than it found in every country persons who devoted themselves to what they considered the improvement of its details: France had its Errard, its Pagan, and its Vauban; the Netherlands its Freitag and its Coehorn; Germany its Speckle; and it may be asserted that the last-named was at least equal to any of the others. Germany, however, though it might have justly prided itself on Speckle, has gone back to Dürer, and adopted from him the other system of flanking defence, which depends on the use of casemated galleries, and of caponnières or casemated works thrown across the ditches. Yet though this has become the result, it is remarkable that the Germans have taken their systems, as exhibited in the most remarkable of their modern works, from a French officer—the celebrated Marc René, Marquis de Montalembert, who was born in 1713, and commenced his military service as an officer of dragoons in 1731. He was a person of very varied acquirements, and became when still a youth a member of the Academy of Sciences of Paris, but fortification and the art of war were his favourite studies. In 1776 he published his celebrated work entitled "*Perpendicular Fortification, or an Essay on Several Methods of Fortifying a straight line, a triangle, a square, and all polygons of any number of sides, giving to their defence a perpendicular direction. Also, Methods of Improving Existing Defences, and rendering them much stronger. Also, Redoubts, Forts, and Field Intrenchments, of a New Construction,*" a colossal work, embracing 11 quarto volumes, enriched with 165 large plates, and which must be considered the source from

which all the modern *inventions* in this branch of fortification have been derived. In referring back to earlier German writers, it appears that Rimpler in 1673 proposed a system which is a combination of bastions with tenailles, and Landsberg one in 1712 which is purely a tenaille system; but both of these adhere to earthen ramparts and parapets, either with revêtements in the first, or without them in the second, and their systems may be therefore considered an extension of the trace of parapet fortification to rampart fortification. But Montalembert, in his tenaille system, replaces the simple revêtement at the re-entering angles with casemated works in two stages, thus affording both direct artillery and musketry for the defence of the ditch and faces of the redans, the remaining portion of the trace being occupied by an earthen couvre-face work, with a detached loop-holed gallery in front of it, being evidently the prototype of Carnot's detatched revêtement. The re-entering casemates were calculated to hold 24 guns in two tiers. Behind the couvre-face was the body of the place of the redan, being also fronted by a casemated gallery, and separated from the couvre-face by an inner wet-ditch. In this system, then, the defence by musketry as well as by artillery is at two levels, the one at a moderate height above the bottom of the ditch, and not, as in the old Italian systems, at the high level of the crest of the parapet. At the gorge of each redan is placed a formidable casemated tower; whilst in front of the main ditch there is a general couvre-face provided also with casemated galleries, a second or advanced ditch, places of arms in front of the re-entering angles, a covered-way, and a glacis.

The polygonal system may be considered as springing directly from Dürer's work of the same name, only in this case the simple earthen ramparts of Dürer are exchanged for a combination of casemated towers, casemated galleries, earthen couvre-faces; and the caponnières, which, as in Dürer's, flank the ditches, assume the more artistic form of bastionettes. In Dürer's polygon the sides were straight or unbroken, but in Montalembert's the centre was thrown back and formed into an Italian bastioned trace, the faces flanking the faces of the caponnière, and again, therefore, exemplifying the difficulty of ensuring perfect flanking defence by any other trace. In forts which formed a triangle or square Montalembert was rich in resources, though the massive casemated tower, casemated galleries, and earthen couvre-faces may be considered the essential elements of all. In France, the views of Montalembert have never been received with enthusiasm, though Cherbourg is fortified in conformity to them, and it was even alleged that the corps du genie was indisposed to receive instruction from an officer of another arm; but it is more reasonable to suppose that the cherished name of Vauban has induced its officers rather to direct their attention to the improvement of the bastioned system, which they have certainly carried to perfection, than to the development of one depending on such different principles. In Germany, on the contrary, Speckle is less known than Vauban, and though probably a thought of Dürer may not enter into the question, Montalembert's systems, founded upon some of his principles, have been readily adopted, and may be studied in the works of defence of Coblentz. In all such works masonry defences or casemated buildings assume a character of the highest importance, but it should not be forgotten that no masonry can resist the force of a *concentrated* fire of heavy guns, and can only be considered safe when protected by earthen masks or couvre-faces. The Maximilian towers of the defences of Lintz, therefore, are not now approved by modern engineers, and the Russians have exhibited their distrust of the most formidable looking masonry defences, even when opposed to ships, by closing the harbour of Sebastopol against approach by sinking a large portion of their own fleet; and this is not to be wondered at, when it is remembered, that to bring the guns forward in order to give them a necessary latitude of fire within casemated batteries, the walls must be much cut into, and therefore greatly weakened. This great defect of masonry defences is well known to engineers, in addition to the further evils of smoke in close casemates, but it is presumed that no one who has read this essay will now imagine that it was necessary to wait to the present epoch for this knowledge, as the earthen mask or couvre-face has been shown to have been applied at a very remote period of the history of the science. In the earliest periods of the Italian fortification, the necessity of increasing the active power of the flanks beyond that which could be obtained by their length alone was strongly felt, and in consequence retired flanks, one rising above the other, were adopted, as well as casemated flanks which admitted of two or more tiers of guns, thus, as in Montalembert's system, obtaining a greater number of guns by extending the battery vertically. At first sight this appears a natural mode of gaining a superiority over the attack, in which the batteries can only be extended laterally, but in practice the retired flanks were soon found to be untenable, as those in front were complete shell-traps, and the casements were practically useless from the difficulty of clearing them from smoke. The systems of Montalembert partake of the same defects; and however imposing the appearance of several successive tiers of guns may be, it should be remembered, that, if covered by the mask, they can only be partially used when the enemy is at a considerable distance, and that the tiers exposed to view may be easily destroyed by the guns of attack of the calibres now used at 500 yards. Several writers have proposed systems based upon similar principles to those of Montalembert, but it is perhaps sufficient here to mention the work of Don Jose Herrera Garcia (*Teoria Analytica de la Fortificacion Permanente*), as it unquestionably affords the most remarkable development of the tower system of defence. Garcia proposes several successive lines of massive casemated buildings or towers, of an egg-shape, connected together with what may be called casemated curtains. The towers are surmounted by a parapet, which at the ends next the enemy is broken into a series of smaller curves, and is retired or independent of the exterior wall or scarp. As each of these towers is defensible of itself, the work of forcing a way through three lines of them would undoubtedly be most formidable, but of course the expense of such a system would be enormous.

The system of the Swedish general Virgin belongs to the bastioned systems, but it is mentioned here in contrast to Garcia's, as it disperses in the defences separate bastioned forts of a form somewhat approaching to Rimpler's, and covered by outworks so arranged as to secure the inner works from injury until the enemy has effected his lodgement upon them. These forts were to be surrounded on all sides by ditches, and connected together by secure communications. Ingenious as Virgin's system is, it is manifest that though the loss of one fort would not ensure the fall of the others, it would at least render all the interior space inclosed by the line of forts untenable, and place the town, the arsenal, or other public buildings, at the mercy of the besiegers. This may be said of all detached forts, and it must be again laid down as a maxim, that the ultimate value of such forts, as a means of securing some important object, depends on an inner line of defence of a nature to resist any sudden attack or *coup-de-main;* and this principle should be applied to the defences of such places as Portsmouth and Gosport. Detached forts will be, for such a purpose, more effectual than a simple continuous line, as they may be so placed as to keep the enemy at a proper distance, but they will cease to be of use if an enemy can safely pass them and attack a defective interior line behind, incapable of resisting a *coup-de-main.*

Zastrow, in commenting on the systems of Montalembert, remarks, "the appearance of the system of Montalembert has overthrown all which was before considered good and excellent," and the Germans have acted upon that dictum both in their teaching and in their constructions; but now another writer, who, like the early Italian writers on the art of fortification, is an architect by profession, has endeavoured to replace the massive masonry works of Dürer and Montalembert by equally massive earthen defences. In his system is seen a ditch 50 feet deep and from 150 to 300 feet wide to afford earth for a rampart rising at its inner crest to about 60 feet above the plane of construction, and formed into five concentric parapets, being in fact so many fausse-brayes of the old Dutch system. Such was the system when first proposed to the consideration of the corps of engineers, but now, is it too much to say, partly from the remarks then offered upon it, the exterior circle has been shaped into something very like a bastioned trace, so as to flank the ditches by strong narrow bastions or caponnières, thus introducing the German or Dürer principle in combination with the Italian one. The Haxo principle of casemated batteries appears to be that adopted by Mr Ferguson for his guns, and he imagines that he can thus gain the increased fire of several tiers of guns without the inconveniences consequent upon casemated masonry buildings. It is to be regretted that Mr Ferguson should have charged upon the corps of engineers illiberality, because they hesitated to publish in their professional papers a scheme of defence not even then matured by its author, and not supported by any estimate of its cost; and further, because they have pointed out that the caponnières or the lower flank of his bastion built up against the earthen scarp would be destroyed with ease at a considerable distance, and the main ditch, when dry, left without defence, as the lofty battery alone could afford it no protection.

So far from engineer officers rejecting improvement, from whatever source it may come, it may be asserted with justice, that they are quite ready to admit the ingenuity of Mr Ferguson, though they may not be prepared to admit that a multiple general intrenchment, without interior flanking defence, would really render a fortress impregnable; and they believe that ere long an accurate description of the works of Sebastopol will prove that the Russians could not have derived their ideas of defence from works which, like those of Mr Ferguson, require ditches of enormous depth, and ramparts of vast height, the work of great time and cost.

It has been well stated by the French translator of Zastrow, that the reduction of a place may be considered as a certain amount of work to be performed, the magnitude of which depends on various elements, amongst which the disposition and nature of the works constitute the most important; and that the attack has to perform this work in a certain time, and with certain means, amongst which the principal elements are the quantity of heavy artillery, and, it may be added, the nature of the ground over which the approaches must be carried. When, therefore, it is said that a work fortified on Vauban's first system would fall on the twenty-eighth day,—on Cormontaigne's, with a cavalier intrenchment in the bastion, on the thirty-first,—it must be remembered that this implies the possibility of steadily advancing the approaches over a soil easily worked by the sapper; but should the ground be rocky, and every inch require to be gained by hard and incessant toil, protracting the time during which the sapper is uncovered, and therefore greatly adding to the daily losses of the trenches, these periods may readily be extended to twice or three times the ordinary length. Southern Sebastopol, for example, has now fallen—the intelligence having arrived whilst these last few pages have been passing through the press—and it has cost a year to obtain this signal triumph over an enemy who has exhibited in its defence the highest qualities of military skill and bravery. In this remarkable siege the assailants have laboured under every disadvantage; they have toiled over ground most difficult to sap, and they have been unable to shut off from the enemy, by a perfect investment, those supplies of stores and men which have changed a garrison into an army, and enabled the defenders to keep up to the last that war of sorties and of intrenchments which was so strongly advocated by Carnot. When at length the Russians yielded up the prize, interior intrenchments were yet existing sufficient to check the progress for a time even of victorious soldiers; but the enemy feeling, that, commanded by the Malakoff, these intrenchments must have fallen before another day's attack, and that their retreat would have been then cut off, abandoned them, and thus again confirmed the experience of more than 150 years, that the attack, when conducted with skill and bravery by an army of sufficient strength, must finally prevail. (J. E. P.)

FORTIFIED ISLAND, an island in the Indian Seas, lying off the coast of Canara, about a mile from the land, a little way north from the entrance to Lake Onore. The island abounds in cocoa-nut, palm, and plantain trees, and has plenty of fresh water. It produces the best kind of cari, which is used by the natives in painting their houses. Its name is derived from its fortifications, which were greatly strengthened by Tippoo Saib, from whom it was taken in 1792 by three British frigates. It is upwards of a mile in circuit. Long. 74. 27. E.; Lat. 14. 16. N.

FORTITUDE, a virtue or quality of the mind, which is generally considered to be the same as courage, though in a more accurate sense the one may be distinguished from the other. Courage may be a virtue or a vice, according to circumstances; fortitude is always a virtue. We speak of desperate courage, but not of desperate fortitude. A contempt or neglect of danger, without regard to consequences, may be called *courage;* and this some brutes possess as well as man. In them it is chiefly the effect of natural instinct; in man it depends partly on habit and partly on strength of nerve. But fortitude being the virtue of a rational and considerate mind, is founded on a sense of honour and a regard to duty.

This virtue takes different names, according as it acts in opposition to different kinds of evil; but some of these are applied with considerable latitude. With respect to danger in general, fortitude may be termed *intrepidity;* with respect to the dangers of war, *valour;* with respect to pain of body or distress of mind, *patience;* with respect to labour, *activity;* with respect to injury, *forbearance;* with respect to our condition in general, *magnanimity.*

The motives to fortitude are many and powerful. This virtue tends greatly to the happiness of the individual, by giving composure and presence of mind, and keeping the other passions in due subordination. To public good it is essential; for without it the independence and liberty of nations would be impossible. It gives to character that elevation which poets, orators, and historians have in all ages rejoiced to celebrate. Nothing so effectually inspires it as rational piety; the fear of God is the best security against every other fear. A true estimate of human life, particularly its shortness and uncertainty, together with the numberless evils and temptations to which, by a long continuance in this world, we must unavoidably be exposed, ought by no means to discourage or throw any gloom on our future prospects, but should teach us that many things

are more formidable than death, and that nothing is lost, but much gained, when, by the appointment of Providence, a well-spent life is brought to a conclusion.

FORTROSE, a royal and parliamentary burgh of Scotland, county of Ross, situated on the N. side of the Moray Firth, nearly opposite Fort-George, from which it is 2½ miles distant, and with which it has regular ferry communication. It was made an episcopal see in the 12th century by David I., but only a small portion of the cathedral now remains. It has a handsome episcopal chapel and academy, and a good harbour, with a depth of 14 feet water at high tide. The parish church is at Rosemarkie, about a mile eastward. Sir James Mackintosh received his early education here. Fortrose unites with Inverness, Forres, and Nairn in returning one member to parliament. Pop. of burgh, which includes Rosemarkie (1851), 1148.

FORTUNA, in *Ancient Mythology*, the goddess of fortune, was worshipped with especial honours in various parts of Italy. Her name does not occur in the earlier Greek authors, who refer the chances of life to the will of Jupiter and the decrees of the Fates. The worship of this goddess seems to have been common in Italy at a very early period. Before the Roman era, the Etruscans (among whom she was known by the name of Nursia) had erected a temple in her honour at Volsinii, and the Latins at Præneste. But the most splendid of all her temples was that at Antium, which Horace has celebrated in his ode beginning—

O Diva, gratum quæ regis Antium,

and of which the *sortes* or oracular responses were very celebrated. Fortuna was sometimes represented as blind, with winged feet, resting on a wheel, at others with a sun and crescent moon on her head. The Romans had a tradition, that when this goddess entered their city she laid aside her wings and sandals, indicating by this means that she intended to remain there for ever. Fortuna is mentioned by Roman writers with a great variety of epithets attached to her name, such as *publica, privata, muliebris, virilis,* &c. &c. At Rome alone the number of her temples amounted to twenty-six.

FORTUNATÆ INSULÆ, the name by which the Canary Islands were known to the ancients. The Carthaginians were no doubt acquainted with these islands at an early period; but it was the selfish nature of their policy to confine such knowledge to themselves, for the sake of the commercial advantages to be derived from it. It was not, therefore, till the fall of Carthage that the Greeks and Romans acquired any accurate information respecting the islands on the west coast of Libya. Statius Sebosus, the friend of Lutatius Catulus, consul 242 B.C., who flourished in the time of the Cimbrian war, could not have been the first who made the discovery, though he was probably the first who gave a description of them to the public. Of this account we possess only a few notices by Pliny, who seems to have derived no information from any other quarter. Yet there must have been considerable intercourse with these islands, as we find that Sertorius, when flying before the superior force of the party of Sylla, was so charmed with the account of them he received from some sailors, that he was strongly tempted to take refuge there. The name seems at first to have been restricted to two, Convallis, the island of *Teneriffe*, and Planaria, now *Canaria*, from which the Canary Islands derive their name. Ptolemy extends the name to six islands. (Strab. i. 3; Plin. vi. 32; Plut. *Sert.* 9; see Miñano, *Diccionario Geografico*, &c., Madrid, 1826.)

FORUM, in *Roman Antiquity*, signified originally the open space in front of any public building, and was afterwards applied to the central square in the ancient Roman cities where public business was transacted, and where in the early ages of Rome causes were tried. The forum of the Romans corresponded to the agora of the Greeks, being commonly oblong rather that perfectly square in form, and was surrounded with temples, public buildings, and porticos. The Roman fora were of two kinds, "civilia" and "venalia;" the former set apart for meetings of the people and the administration of justice, and the latter for purposes of trade. The city of Rome itself contained nineteen important fora—the forum Antonini, Archemorium, Argentarium, Augusti, Boarium, Cæsaris, Cupidinis, Nervæ, Olitorium, Piscarium, Piscatorium, Pistorium, Romanum, Sallustii, Suarium, Trajani, Transitorium, and Vespasiani. Of these the forum Romanum, Nervæ, Trajani, Boarium, and Piscatorium still present many interesting remains of the magnificent edifices with which they were once adorned. By far the most important of the ancient fora was the Forum Romanum, which was for a long time the only one of its kind, and was at first known as *the* forum. In later times, when their number was greatly increased, it was distinguished from the others by the epithets of *vetus* or *magnum.* It was seven "jugera" or acres in extent, and was situated in the low ground between the Palatine and Capitoline hills, not very far from the Tiber; but it does not seem possible now to fix its exact limits. It was surrounded on every side by the most splendid buildings of the ancient city—temples, basilicæ, triumphal arches. It contained also many statues of illustrious Romans, and the *rostra* or stage from which the people were addressed, so called from its being adorned with the beaks of ships taken from the Antiates in the early wars of that people with the Romans. The forum, in its widest sense, appears to have comprised the comitium (or place of assembly for the curiæ), which was separated from the forum (in its narrower sense the place of meeting of the comitia tributa) by the rostra. Originally, orators, when addressing the people from the rostra, looked towards the comitium and the curia; but the younger Gracchus got a law passed compelling them to face the forum, and thus acknowledge the sovereignty of the people. In the comitium or upper part of the forum the laws of the Twelve Tables were exposed for public inspection, and the Fasti were afterwards exhibited there on white tables that the citizens might know on what days it was lawful to transact legal business. In 308 B.C. the forum was adorned with the gilt shields taken from the Samnites, and these trophies of Roman valour were afterwards annually exhibited there during the Ludi Romani. One of the most interesting ornaments in the forum was the Columna Rostrata, on which were hung the beaks of the Carthaginian ships taken by the consul Duilius in the first Punic war. Besides the forum Romanum there were two other *fora* judiciaria at Rome, one of them built by Julius Cæsar, and the other by Augustus, to provide for the great increase of public business during their supremacy. None of the other fora were at all to be compared either in size or splendour with these three. A beautiful restored view of the Forum Romanum was designed by Mr C. R. Cockerell, of which a reduced plan was published in the "Pompeii" of the Society for the Diffusion of Useful Knowledge.

FOSCARI, FRANCESCO, the celebrated doge of Venice, was elected to that office in 1423, and retained it for 34 years, dying in 1457, three days after his resignation. He did good service to his country, both by his foreign conquests and the excellence of his home administration. His domestic relations, however, were singular. He had the misfortune to lose three of his sons, and to see a charge of treason brought against the fourth and last, who was put on the rack and tortured before his own eyes, while he was himself compelled to acknowledge the justice of the whole trial. A very detailed and excellent account of the subsequent persecution of Foscari and his unfortunate son will be found in the second volume of Smedley's *Sketches of Venetian History*. Byron's tragedy of the *Two Foscari* is based upon this narrative.

FOSCOLO, Ugo, a distinguished Italian poet and miscellaneous writer, was born about 1777 on board a Venetian frigate, near Zante, in the Ionian Sea. While a mere boy he had the misfortune to lose his father, who was a physician and government-inspector of hospitals at Spalatro, in Dalmatia. He studied at the university of Padua, and after completing his studies there he removed to Venice without having adopted a profession. A good deal of mystery hangs over this period of his life, but he seems to have been preparing for a literary career, and produced in 1797, as the first fruits of his labours, his tragedy of *Thyestes and Ajax*. This play had very equivocal success on the stage, and so strongly was its author convinced of its worthlessness that he himself penned the severest criticism of it that appeared anywhere. In that same year the French, who with Bonaparte at their head had taken Venice with the professed object of republicanizing it, made it over once more to the Austrians. Foscolo, with some of the leading members of the patriotic party, retired to Milan, where he gave vent to his excited feelings in his *Lettere di Due Amanti* (afterwards republished under the title of *Le Ultime Lettere di Jacopo Ortiz*), a sort of political romance which had an immediate and prodigious success. The work possesses little interest as a novel, but is valuable for its pictures of Italian society in those troubled times, its beautiful style, its pathetic tone, and its occasional bursts of impassioned eloquence. In 1799 Foscolo volunteered into the Lombard legion, served in the disastrous campaign of that year, took part in the defence of Genoa under Masséna, and, after the battle of Marengo once more threw Lombardy into the hands of the French, retired into private life at Milan, and resumed his literary pursuits. In 1802 Bonaparte called together at Lyons a meeting of Italian deputies to sketch the plan of a constitution for the Cisalpine Republic, and Foscolo was invited to lay before the First Consul the real state of the country and the wishes of the people. He executed this commission with a boldness so startling that it was judged unsafe to submit the document to the First Consul; but it was afterwards printed at Milan, and serves to set in a very clear light the high and uncompromising spirit of its author. Italy had not heard her political condition and wants so boldly described since the days of Rienzi, perhaps of Tacitus. In 1807 Foscolo served, with the grade of captain of the staff, in an Italian regiment that belonged to the army destined for the invasion of England. In his leisure moments at St Omer he studied alternately military tactics and English literature, and executed part of a highly successful Italian version of Sterne's *Sentimental Journey*. After the breaking up of the camp at Boulogne, Foscolo abandoned the career of arms and retired to Brescia, where he composed his little poem *Dei Sepolcri*. This work, elicited by an order which forbade the erection of any memorial to departed worth or genius, was dedicated to Pindemonte, a kindred spirit, and immediately took rank as one of the highest flights of lyric power in the literature of modern Italy. In 1808 Foscolo was appointed professor of belles-lettres in the university of Pavia, and was privately warned by certain official friends to inaugurate his lectures with a tribute of praise to the Emperor Napoleon. Instead of doing this, though tempted with the promise of the cordon of the legion of honour, Foscolo delivered an opening address on the *Origin and Duty of Literature*, glowing with such a fiery eloquence, and informed by so daring a spirit of independence, that the orator incurred the suspicions of the government, and his chair was shortly afterwards suppressed. His tragedy of *Ajax*, though it had no great success when produced on the stage at Milan, did not tend much to conciliate for him the favour of the authorities, as it was believed that under the names of Agamemnon, Ajax, and Calchas, he had intended to paint Napoleon, Moreau, and Pius VII. A satire on the pedantry and sycophancy of certain influential academicians raised against him such a host of enemies that he was obliged to retire for a short time from Milan. At Florence, to which he now removed, he completed his translation of the *Sentimental Journey*, and produced his tragedy of *Ricciarda*, besides a variety of minor poetical pieces. In the political history of Northern Italy, after the abdication of Napoleon, Foscolo played a prominent part; but finding it useless to contend against the overwhelming numbers of the Austrians, he being moreover accused of tergiversation by his own party, he suddenly quitted Italy and fixed his residence at Hottingen near Zurich in Switzerland, where he earned a scanty livelihood for two years by his pen. In 1816, with a view to bettering his fortune, he came to England, where he formed literary connexions, and wrote many articles for the *Edinburgh* and *Quarterly Reviews*. In London he republished his *Ricciarda*, and wrote historical disquisitions on Dante, Petrarch, and Boccaccio, all displaying great knowledge and much critical sagacity. At the time of his death, which happened in 1827, he was engaged in superintending a valuable edition of Dante. His death, which was caused immediately by an attack of dropsy, was accelerated by pecuniary embarrassments which fretted his naturally irritable temper, and impelled him to literary exertion quite beyond his physical strength. Though the character of Foscolo was dashed by some strange eccentricities, he yet possessed qualities, both of head and heart, which gained firm friends for him in every country where he happened to fix his residence. The most striking of these peculiarities was his vanity, which prompted him in society to talk far more about his own exploits and sufferings than was consistent either with modesty or self-respect. This same weakness showed itself in his dramatic works, in which the hero is generally the *alter ego* of himself, and probably prevented him from realizing the prophecy which Alfieri made about him on witnessing his first play, and hearing that the author was only nineteen years of age:—"If that be true," said Alfieri, "then he will excel me." But this infirmity was far more than atoned for by the lofty independence of his character, which in the general prostration of Italy before Napoleon, enabled him to stand aloof, and offer the only opposition which that conqueror experienced from any native-born Italian. In the words of Pecchio, the biographer of Foscolo, "If, amidst the Asiatic idolatry towards Napoleon, any kind of opposition can be said to have existed in Italy, Foscolo must be considered the leader of it. Among a crowd of literati, who prostituted their character, he alone succeeded Alfieri in gathering around him those youths who felt the love of study and independence, and without uselessly challenging an irresistible power, he tempered with his principles and example their souls for present dignity and future resistance." Foscolo was no partizan, and refused to associate with such of his own countrymen as would have been content with anything less than the absolute and unconditional independence of Italy. His aspirations in literature and politics were high and noble, and his talents were never employed except in the cause of virtue. His dramatic productions are not very valuable; but his prose works are in point of style and matter among the most vigorous and original in the literature of modern Italy.

FOSSE, or Foss (from *fossus*, part. of *fodio* to dig), in *Fortification*, a ditch or moat; in *Anatomy*, a peculiar cavity in a bone, with a large aperture.

FOSS-WAY, a Roman military road in England, leading from Totness through Exeter to Barton on the Humber, and so called, says Camden, from the ditch on both sides.

FOSSANO, a city of Piedmont, province of Coni, Sardinia, situated on a lofty hill near the left bank of the Stura, 15 miles N.N.E. of Coni. The hill is crowned with an old castle, and the town itself is encircled by walls. It has an antique and rather gloomy appearance, the houses being

built upon ranges of arches under which are the footways. It has a cathedral, royal college, mineral baths, and manufactures of silk, paper, and leather. Pop. 16,000.

FOSSARII, in the ancient Eastern Church, officers appointed to bury the dead. Ciacconius relates that Constantine created 950 fossarii, and that they were exempted from taxes, services, burdensome offices, and the like.

FOSSIL, in a general sense, denotes anything that is dug out of the earth. But the word is generally used among geologists and mineralogists to designate either simple or compound mineral bodies, such as metals, stones, salts, earths, and other minerals, or, more commonly, the petrified forms of plants and animals which occur in the several strata of the earth. *Native* fossils are minerals, properly so called, as earths, salts, metallic bodies, &c. *Extraneous* fossils are bodies of the animal or vegetable kingdoms, accidentally buried in the earth; such as plants, shells, corals, bones, and other substances, most of which exist in a petrified state. See Geology.

FOSSOMBRONE, the ancient *Forum Sempronii*, a town of the Papal States, legation of Urbino e Pesaro, situated on the Metauro, here crossed by a handsome one-arched bridge, 7 miles E.S.E. of Urbino. The cathedral contains many good paintings and interesting inscriptions. In the vicinity, Asdrubal the brother of Hannibal was defeated and slain (207 B.C.) by the Romans. The inhabitants, amounting to about 5000, are chiefly engaged in agriculture, and in the manufacture of silk, which is said to be the finest in Italy.

FOSTER, John, generally distinguished as "*The Essayist*," was born in the parish of Halifax, Yorkshire, Sept. 17, 1770. His parents occupied a small farm-house between Wainsgate and Hebden-bridge, and maintained themselves partly by farming and partly by weaving. They were persons of earnest piety, and of strong intelligence, though of limited cultivation, with little book-knowledge except such as they obtained from some ponderous volumes of Puritan theology. They married rather late in life: John was their first-born, and they had no other child besides his brother Thomas, who was four years younger—circumstances not favourable to the development of the social qualities. From childhood his character was marked by a sharply-defined individuality. To use his own expressive language, he felt "as if dissociated from the whole creation," and recoiled from human beings into a cold interior retirement. His outward life was marked by timidity and "infinite shyness;" his interior life was crowded and agitated with incommunicable feelings. His antipathies were strong, though not malicious, and his associations intensely vivid. For a number of years he would not sit on a stool which belonged to a man who died in a sudden and strange way, and whose ghost was said to have appeared in a barn near his house. His emotions were strongly roused by passages in favourite authors, such as Young's *Night Thoughts*. Single words (as *chalcedony* or *hermit*) or the names of ancient heroes had a mighty fascination for him. But while he felt isolated and shut out from human sympathy, he found relief and exquisite delight in the contemplation of natural scenery. "Sweet nature!" he exclaimed many years after, "I have communed with her with inexpressible luxury." A flower, a tree, a bird, a fly, was enough to kindle a delightful train of ideas and emotions, and sometimes to elevate the mind to sublime conceptions. Yet, in very early life, the *great* interested him more than the *beautiful*. Great rocks, vast trees and forests, emphatically dreary, caverns, volcanos, cataracts, and tempests, were, in reading and fancy, the objects of his highest enthusiasm; and in the contemplation of human character he preferred the bold and the heroic. Filled with restless thoughts and aspirations, he felt as a foreigner in his native place, and some of his earliest musings were on plans for leaving it. The dull monotonous occupation of weaving, in which he assisted his parents, and the utter want of sympathy in those around him, increased his disgust with his position. He performed the tasks assigned him with evident signs of repugnance, and in a manner which showed little aptitude for them; yet his general conduct was exemplary, reverential to his parents, and very free from any marked irregularity.

As a compensation for much that was undesirable in his social relations, the moral and religious influences he was under were powerful and salutary. His impressions of religion assumed as early as his fourteenth year a decided form. Just after the completion of his seventeenth year he joined the religious society of which his parents were members—that of the Baptist denomination—at Wainsgate Their pastor was Dr John Fawcett, a man venerable for his piety, with talents devoid of brilliancy but assiduously cultivated, and who combined with a puritanic theology an extensive acquaintance with English literature (including works of fiction), which placed him, in point of mental cultivation, far ahead of his co-religionists in Yorkshire and the neighbouring districts. For many years Dr Fawcett conducted a flourishing seminary at Brearley Hall, which was subsequently carried on by his son at Ewood Hall. With him young Foster was placed for the purposes of general education and of preparation for the ministerial office, in accordance with his own inclination and the wishes of his friends, who had some perception of his mental superiority. Part of each day was still spent in his customary employments at home; but, to make up for this interruption of his studies whole nights were frequently devoted to reading and meditation, *sub dio*, in his preceptor's garden. His school exercises were accomplished slowly and laboriously, which was the case with all his literary performances. At Brearley he had access to a large and miscellaneous library; he was most interested with voyages and travels, and these constituted throughout life his favourite reading. On leaving Brearley he proceeded to the Baptist college at Bristol, at that time (1791) and for some years later the only theological institution belonging to that denomination. The Rev. Joseph Hughes, the originator and dissenting secretary of the Bible Society, was then the classical tutor, having succeeded Robert Hall, who had just removed to Cambridge. Foster remained only a twelvemonth at Bristol, and, if his own statement be taken as correct, without much improvement in scholarship; but during that period he gained the friendship of Hughes, visited Hannah More and her sisters at Cowslip Green, and listened for the first time to the eloquence of Hall. On leaving Bristol he spent three months at Newcastle-on-Tyne, where he preached to a very small audience, and whiled away his leisure time in desultory musings, conscious of possessing superior powers, but neither happily combined nor fully brought out. After visiting his Yorkshire friends he went to Ireland, where he spent little more than a year, in Dublin, first as a preacher, and then as a schoolmaster, but failed to establish himself in either capacity. Early in 1797 he became the minister of a general Baptist church at Chichester; here he remained for two years and a half, and though his religious earnestness increased, it produced little effect on his hearers. We next find him at Battersea, visiting his friend Hughes, and instructing twenty-one young Africans brought over by Zachary Macaulay from Sierra Leone. In 1800 he removed to Downend, a village five miles from Bristol, and preached alternately in a small chapel there, and in another at Fishponds belonging to a lunatic asylum then under the management of Dr Joseph Mason Cox, whose brother-in-law he afterwards became. In 1804, on the recommendation of Robert Hall, who described him as "a young man of the most original and extraordinary genius, of unexceptionable character, and of the most amiable temper," he became minister of a congregation at Frome. The characteristics

Foster.

of his preaching at this period have been traced with great fidelity by his friend (and constant hearer) Mr Sheppard. "The sermons of Foster," he remarks, "were of a cast quite distinct from what is commonly called oratory, and indeed from what many seem to account the highest style of eloquence, namely, a flow of facile thoughts through the smooth channels of uniformly elevated polished diction, graced by the utmost appliances of voice and gesture. They were distinguished by an unambitious and homely sort of loftiness, which displayed neither phrase nor speaker, but things, while the brief word and simple tone brought out the sublime conception 'in its clearness' by a fund of varied associations and images, by graphic master-strokes, the frequent hints of profound suggestion for after meditation, by cogent though calm expostulations and appeals, and by shrewd trains of half-latent irony against irreligion and folly, in which, without any descent from seriousness and even solemnity, the speaker moved a smile by his unconscious approach to the edge of wit, yet effectually quelled it by the unbroken gravity of his tone and purpose."

After two years a swelling in the thyroid gland, which constant public speaking, and even much talking in company, tended to aggravate, obliged Mr Foster to resign his charge at Frome. He had also a growing conviction that the press, and not the pulpit, was the chief medium through which he could efficiently employ the talents committed to his trust. For some time, evidently with a view to authorship, he had committed to paper observations on natural objects, illustrations of human character, and reflections on morals and religion, in an aphoristic form. Many of these contain the germ, and even the exact phraseology, of passages to be found in his published writings. During his residence at Frome he wrote and published the *Essays*, which at once established his reputation "as (to use Sir James Mackintosh's language) one of the most profound and eloquent writers that England has produced." Within little more than a twelvemonth they passed through three editions; the eighteenth appeared in 1845, and since that time their circulation has been unabated. Multitudes of young persons have regarded as a bright era in their mental history the hour when this volume first came into their hands, and have never ceased to rejoice in its stimulating and elevating influence on their faculties. It has been to them a dayspring revealing a world of living beauty and wonders where all was before involved in deathlike torpor and gloom. Its intellectual power and deep-toned eloquence has dissolved in many minds the unhappy and absurd association of piety with mental weakness and vulgarity; while, on the other hand, it has released from their trammels not a few who had been wont to regard general literature and freedom of thought as the exclusive property of the profane. The last of the four essays, *On some of the Causes by which Evangelical Religion has been rendered unacceptable to Persons of Cultivated taste*, has probably contributed more than anything else to that reformation in style which is perceptible in our modern religious literature, and of which Foster himself in his posthumous lectures has given so many beautiful specimens.

Before leaving Frome, Foster commenced writing in the *Eclectic Review*, and for the next twelve years contributed from ten to above twenty articles annually. In May 1808 he married the lady to whom his Essays were originally addressed in an epistolary form, and with whom his acquaintance had commenced seven years before at Battersea. Her mother and two of her sisters resided at Bourton-on-the-water, a retired, respectable village in Gloucestershire. To this place he removed on his marriage, which proved an eminently happy one. Here he led a very secluded life, writing reviews during the week, and on Sundays preaching in the neighbouring villages: the latter employment he valued as aiding his own piety, and keeping up an acquaintance with mankind. While at Bourton he lost both his parents, and became the father of five children, two of whom died in infancy. In 1817 he returned to Downend, where he wrote his *Essay on the Evils of Popular Ignorance*, in which he warmly urges the necessity of a national system of education, and portrays with appalling truthfulness the barbarism existing in our masses; a repulsive spectacle, which he terms "a gloomy monotony: death without his dance." Having relinquished his ministerial office at Downend, and removed to the neighbouring village of Stapleton, about two miles from Bristol, he delivered a series of discourses at Broadmead chapel, which were well attended by persons of almost all denominations. On Robert Hall's settlement in Bristol, he declined to continue this service, saying, "Now *Jupiter* is come, I can try it no more." Most of these discourses were published soon after his decease, and have lately been reprinted by Mr Bohn in his Standard Library. In 1826 his only son, an amiable, thoughtful youth, died of consumption. Six years later he was deprived of his inestimable wife, to whom he felt himself indebted not only for a very great portion of happiness, but for whatever mental improvement he had made during their married life, a period of five and twenty years. Her intellect was remarkably strong and correct, and in refinement of perception and depth of reflective feeling she had few equals. This event deepened his constitutional pensiveness, and prompted him to indulge more than ever in those intense musings on the state after death, "the secrets of the invisible world," which form an ever-recurring topic in his correspondence. In addition to this greatest loss, he found himself, by the deaths of Hall, Hughes, and others, standing almost alone, bereft of the companions of his youth and mature life. His latter days were, however, soothed by the affectionate attentions of his two daughters who resided with him. After languishing for some weeks in a state of devout preparation for the final event to which he looked forward with a calm dignity and a childlike humility that were most impressive, he expired quietly and (as he wished) alone, October 15, 1843.

Besides the works already mentioned, Foster published a *Discourse on Missions* in 1818; an *Introductory Essay to Doddridge's Rise and Progress of Religion* (since reprinted separately) in 1825; and *Observations on Mr Hall's Character as a Preacher*, appended to Dr Gregory's Memoir in the collected edition of Hall's Works, 1832. He also wrote *An Introduction* to a pamphlet by Dr Marshman in vindication of the Serampore Missionaries. He was the author (anonymously) of *Two Letters on the Established Church*, addressed to the editor of the *Morning Chronicle*; and of *Five Letters* (in the same journal) *on the Ballot*, of which he was a strenuous advocate; these and *Nine Letters of Religious Advice and Consolation* to an interesting young person (the niece of his friend Mr Cottle) in her last illness, will be found in his *Life and Correspondence*, 2 vols., the third edition of which has lately appeared in Bohn's Standard Library.

His contributions to the *Eclectic Review* amounted to 185 articles, of which Dr Price published a selection, containing 59 papers, in 1844. (J. E. R.)

Fothergill.

FOTHERGILL, Dr John, an eminent physician, was born of Quaker parents, in 1712, at Carr End in Yorkshire. The doctor was the second of five children, and received his education under the care of his grandfather Thomas Hough, a person of fortune in Cheshire, and at Sedburgh in Yorkshire. Having served his time to an apothecary at Bradford, he removed to London, and became a pupil of Dr Wilmot, at St Thomas's Hospital. He then went to the university of Edinburgh for the purpose of studying medicine, and there took his degree. From Edinburgh he went to Leyden: but after a short stay he returned to London, and began to practise about the year 1740, in a

house in White-hart Court, Lombard Street, where he resided during the greater part of his life, and acquired most of his fortune. In 1746 he was admitted as a licentiate of the College of Physicians in London; and in 1754 as a fellow of that of Edinburgh, to which he was a considerable benefactor. He afterwards became a member of the Royal Medical Society at Paris, as well as of the Royal and Antiquarian Societies. He continued his practice with uninterrupted success till within the last two years of his life, when an illness, which had been brought on by unremitting labours, obliged him to give up a considerable part of it. Besides his application to medical science, he had imbibed an early taste for natural history, and devoted his leisure to conchology and smaller objects of botany. His pamphlet on the ulcerous sore throat is the best of his publications, but it owes much of its merit to the prior information of Dr Letherland. It was printed in the year 1748, on the re-appearance of that fatal disorder which in 1739 had carried off the two sons of Mr Pelham. He was the patron of Sidney Parkinson, and drew up the preface to his account of the voyage to the South Seas. At his expense also was made and printed an entirely new translation of the Bible, from the Hebrew and Greek originals, by Anthony Purver, a Quaker, in two volumes, 1764, folio; and also, in 1780, an edition of Bishop Percy's *Key to the New Testament*, adapted to the use of a seminary of young Quakers at Ackworth. In the influenza of 1775 and 1776, he is said to have had sixty patients on his list daily, and his profits were estimated at L.8000 per annum. The disorder which hastened his death was a schirrus of the prostate gland, and an obstruction of the bladder. He died at his house in Harpur Street, in the month of December 1780, and his remains were interred in the Quakers' burying-ground at Winchmore Hill. The doctor by his will appointed that his shells and other specimens of natural history should be offered to Dr Hunter at L.500 under the valuation which he had ordered to be taken of them, and accordingly Dr Hunter bought them for L.1200. His drawings and collections in natural history were also offered to Sir Joseph Bankes at a valuation. His English portraits and prints, which had been purchased by him for eighty guineas, were bought by Mr Thane for two hundred guineas. His books were sold by public auction.

FOTHERINGAY CASTLE, in which Mary Queen of Scots was long confined, and was beheaded 8th Feb. 1587, is situated in Northamptonshire, 3½ miles N.N.E. of Oundle. It was demolished by order of her son, James I. of England.

FOUCHÉ, Joseph, Duke of Otranto, minister of police under Napoleon, was born at Nantes in 1763. In the oratoire of that city where he was educated he distinguished himself by his proficiency in the various departments of study, and on leaving it taught successively in the colleges of Juilly, Arras, and Vendôme. The outbreak of the Revolution found him settled quietly in his native town, practising as an advocate. In 1792 he was returned to the National Convention as member for the department of Loire Inférieure, and in this capacity voted for the death of the king, without the right of appeal to the people. Having earned the character of a zealous republican by his conduct at Nièvre, where he suppressed public worship, plundered the churches, imprisoned the priests, and decreed materialism by inscribing over the entrance to the town cemetery, "La mort est un Sommeil éternel." Fouché was associated with Collot d'Herbois in that frightful mission which razed Lyons to the ground, and deluged the south of France with blood. On his return to Paris he was made president of the Jacobin Club, though he was shortly afterwards expelled from it altogether by the intrigues of Robespierre. Fouché avenged this disgrace by doing his best to bring about the downfall and death of Robespierre; but he was himself seized and imprisoned as a dangerous terrorist; and though he was released under the act of general amnesty in 1795, yet, finding his enemies become more numerous and powerful, he judged it prudent to retire for a while into the obscurity of private life. In 1798 he was engaged in the public service in Italy; and on returning home was appointed to the ministry of police, a situation for which he was eminently qualified by his unscrupulous boldness, his matchless cunning, and his capacity for intrigue. Having assisted Bonaparte in his rise, he was continued in office, and contrived to stand well both with that conqueror and with the royalists, whom he frequently screened from Napoleon's vengeance. In the foreign wars of the emperor, Fouché's system of espionage preserved the internal tranquillity of France. Sometimes, as in the case of the English expedition against Holland in 1809, he acted with an independent boldness that accorded very ill with the dictatorial mind of his master. On that occasion he called forth the national guard; and in his address to them said, "Let us show Napoleon that his presence is not indispensable for the repulsion of the enemies of France." Napoleon both hated and feared him, but wisely consulted his own interests in employing and promoting him. In 1809 Fouché was made Duke of Otranto, but was obliged in that year to retire into the country for a time. In 1810 he was made governor of Rome, and in 1813 of the Illyrian provinces, and afterwards of Naples. During the Hundred Days he resumed his old functions of minister of police, and after Waterloo strongly urged Napoleon to abdicate, while he secured his own interest with the Bourbons at Ghent. His services were retained for a while by Louis XVIII.; but in 1816 he shared the fate of the surviving revolutionists who had voted for the death of Louis XVI., was banished from France, and deprived of his estates. He died at Trieste in 1820, leaving behind him an enormous fortune. His memoirs, which were published in France in 1824, were not acknowledged by his sons; but there are good reasons for believing them to be authentic. Various attempts have been made to defend the character of Fouché, but with very indifferent success. The best thing that can be alleged in his favour is, that he does not appear to have been a coward. It is to be doubted if the French Revolution produced a worse man than Fouché. He was only less bloodthirsty than Collot d'Herbois, and less of a hypocrite than Barrère. In cunning and the unscrupulous abuse of great power, a parallel, or even a second to him is not to be found in these disjointed times. In such a man it would be too much to look for honesty of purpose or single-heartedness of aim, and accordingly we find him, though fulfilling his official duties as they never were fulfilled before or since, animated throughout his whole career solely by the principle of an ambitious self-interest. He succeeded so well, that it may be doubted if even Napoleon himself exercised a more despotic power in France during the period of his reign than did his formidable minister of police. Much light is thrown on Fouché's character, and the hidden workings of his political machinery, in the *Témoignages Historiques, ou quinze ans de haute police sous Napoléon*, par Desmarets.

FOUGASSE, in the art of war, a small mine in which the chambers are placed from 3 to 10 feet under ground, dug under some work, fortification, or post, and charged with sacks of powder, or powder placed in a chest, and covered with earth and stones. They are very efficient in defending works, especially if placed near the foot of the glacis or ditch. The powder is fired, as in larger mines, by means of a saucisson. Fougasses are also formed by burying several loaded shells with the fuse downwards.

FOUGÈRES, the capital of a cognominal arrondissement in the department of Ille-et-Vilaine, France, stands on an eminence near the left bank of the Nançon, 24 miles N.E. of Rennes. This was formerly one of the strongest

places in Brittany, and frequently figures in history from the eleventh to the fifteenth centuries. It was taken by the English in 1202, and again in 1448. During the last century it suffered from four destructive fires, so that few of its ancient buildings now remain. It is a pleasant town, and has some mineral springs, which attract numerous visitors. Its trade and manufactures are considerable, the former in agricultural and dairy produce, the latter of sail-cloth and hempen fabrics, flannels, hats, leather, &c. Pop. (1851) 8771.

FOULA, or Fowla Island, one of the Shetland Isles, lying between six and seven leagues west from Mainland. It is about three miles in length, narrow, and full of rugged, steep, and bare rocks. Its summit has an elevation of 1350 feet. Foula, it has been conjectured, is the Thule of Tacitus. It is pastoral, and maintains a few families.

FOULAHS, a people of Africa. See Africa, vol. ii., p. 222.

FOULIS, Robert and Andrew, supposed to have been natives of Glasgow, were two learned printers, and passed their lives in comparative obscurity. They succeeded, however, in establishing a press, and from it issued some of the most accurate and elegant editions of standard works that were produced during the eighteenth century. Robert's first attempt was about 1740, which ended in the publication of an excellent 4to edition of *Demetrius Phalereus* in 1743. Next appeared his immaculate 12mo edition of Horace, of which the sheets, as they were struck off, were suspended in the college at Glasgow, and a reward offered to those who should point out an inaccuracy. Soon after the publication of this famous edition of Horace, the brothers entered into partnership, and continued during 30 years to issue a series of the classics and other works, printed in the most accurate and elegant manner. Of these the most remarkable are the small editions of Cicero, Tacitus, Cornelius Nepos, Virgil, Tibullus and Propertius, Lucretius, and Juvenal; a beautiful edition of the Greek Testament, in small 4to; Homer, fol. 4 vols., 1756-1758; Herodotus, Greek and Latin, 9 vols. 12mo, 1761; Xenophon, Greek and Latin, 12 vols. in 12mo, 1762-1767. To these we may add Gray's Poems; Pope's Works; Hales of Eton, &c.

It is sad to relate that these learned, indefatigable, and successful men were at length ruined by their taste for the fine arts. This was brought about by their establishment of an academy for the instruction of youth in sculpture and painting, but chiefly by the enormous expense incurred in sending young artists to Italy to copy the ancients. They found the city of Glasgow a very ungenial soil into which to transplant the imitative arts; and thus after having realized ample fortunes by their classical publications, they died in poverty, after having parted with the last of their paintings at Christie's in Pall Mall. Andrew died in 1775, and Robert in 1776.

FOULQUES, the name of a distinguished French family, which produced a number of famous warriors and counts of Anjou. The principal of them were—Foulques I., called *le Roux*, Count of Anjou, who succeeded his father, Ingelger, in 888 A.D. He made war upon the Bretons and Normands, and died in 938. Foulques II., called *le Bon*, son of the preceding, and succeeded by Geoffroi I.; Foulques III., called *Nerro* or *le Noir*, son of the last-mentioned; Foulques IV., called *le Rechin*; and Foulques V., called *le Jeune*, son and successor of the preceding, in the year 1109.

FOUMART, the pole-cat. See index to Mammalia.

FOUNDERY, or Foundry, the art of melting and casting metals. See Copper-Smelting; Iron-making; Furnace.

Foundery of Small Works, or Casting in Sand. The sand commonly used for casting small works is at first of a pretty soft, yellowish, and clammy nature; but it being necessary to strew charcoal dust in the mould, it at length becomes of a quite black colour. The sand is worked over and over, on a board, with a roller and a kind of knife; and is placed over a trough to receive it, after it has by these means been sufficiently prepared.

This being done, the workmen take a wooden board of a length and breadth proportional to the things to be cast, and putting a ledge round it, they fill it with sand a little moistened, to make it duly cohere. They then take either wood or metal models of what they intend to cast, and apply them to the mould, and press them into the sand so as to leave their impression there. Along the middle of the mould is laid half a small brass cylinder, as the chief canal for the metal to run through, when melted, into the models or patterns; and from this chief canal are placed several others, which extend collaterally to each model or pattern placed in the frame. After this frame is finished, they take out the patterns, by first loosening them all round, that the sand may not give way; then they proceed to work the other half of the mould with the same patterns in just such another frame, only that it has pins, which, entering into holes corresponding to it in the other, make the two cavities of the pattern fall exactly on each other.

The frame, thus moulded, is carried to the melter, who, after extending the chief canal of the counterpart, and adding the cross canals to the several models in both, and strewing mill dust over them, dries them in a kind of oven prepared for the purpose. Both parts of the mould being dry, they are joined together by means of the pins; and to prevent them giving way, by reason of the melted metal passing through the chief cylindrical canal, they are screwed or wedged up as in a press.

Whilst the moulds are thus preparing, the metal is fusing in a crucible of a size proportional to the quantity of metal intended to be cast. When the moulds have cooled, the frames are unscrewed or unwedged, and the cast work is taken out of the sand, which sand is worked over again for other casting.

Foundery of Statues. The casting of statues depends on the due preparation of the pit, the core, the wax, the outer mould, the inferior furnace to melt off the wax, and the upper to fuse the metal.

The pit is a hole dug in a dry place, somewhat deeper than the intended figure, and made according to the prominence of certain parts of it. The inside of the pit is commonly lined with stone or brick; but when the figure is very large, they sometimes work on the ground, and raise a proper fence to resist the impulsion of the melted metal. The inner mould, or core, is a rude mass, to which is given the intended attitude and contours. It is raised on an iron grating strong enough to sustain it, and is strengthened within by several bars of iron. It is generally made either of potters' clay mixed with cow-hair, or of plaster of Paris mixed with brick-dust. The use of the core is to support the wax and the shell, and lessen the weight of the metal. The iron bars and the core are taken out of the brass figure through an aperture left in it for that purpose, which is soldered up afterwards. It is necessary to leave some of the iron bars of the core, which contribute to the steadiness of the projecting part, within the brass figure. The wax is a representation of the intended statue. If it be a piece of sculpture, the wax should be all from the hand of the sculptor himself, who usually forms it on the core; though it may be wrought separately in cavities, moulded on a model, and afterwards arranged on the ribs of iron over the grating, filling the vacant space in the middle with liquid plaster and brick dust, by which means the inner core is proportioned as the sculptor carries on the wax. When the wax, which is of the intended thickness of the metal, is finished, small waxen tubes perpendicular to it from top to bottom are filled, to serve both as canals for the conveyance

of the metal to all parts of the work, and as vent-holes to give passage to the air, which would otherwise occasion great disorder when the hot metal came to encompass it.

The work being brought thus far, must be covered with its shell, which is a kind of crust laid over the wax, and which being of a soft matter, easily receives the impression of every part, which is afterwards communicated to the metal upon its taking the place of the wax, between the shell and the mould. The matter of this outer mould is varied according as different layers are applied. The first is generally a composition of clay and old white crucibles well ground and sifted, and mixed up with water to the consistence of a colour fit for painting; and it is applied with a brush, by means of which it is laid on seven or eight times successively. For the second impression horse-dung and natural earth are added to the former composition; but for the third impression only horse-dung and earth are used. Lastly, the shell is finished by laying on several more impressions of this last matter, made very thick with the hand. The shell, thus finished, is secured by several iron girths bound round it, at about half a foot distant from each other, and fastened at the bottom to the grating under the statue, and at top to a circle of iron where they all terminate.

If the statue be so large that it would not be easy to move the moulds with safety, these must be wrought on the spot where it is to be cast. This is performed in two ways. In the first place, a square hole is dug in the ground, much larger than the mould to be made therein, and its inside is lined with walls of freestone or brick. At the bottom is made a hole of the same materials, with a kind of furnace, having its aperture outwards; and in this a fire is made, to dry the mould, and afterwards melt the wax. Over this furnace is placed the grating, and upon this the mould, formed as above. Lastly, at one of the edges of the square pit is made another large furnace, to melt the metal. In the other way, it is sufficient to work the mould above ground, but with the precaution of a furnace and grating underneath. When finished, four walls are run around it, and by its side a melting furnace is prepared. For the rest, the method is the same in both cases. The mould being finished, and inclosed as described, whether below ground or above it, a moderate fire is lighted in the furnace under it, and the whole covered with planks, that the wax may melt gently down, and run out at pipes contrived for that purpose at the foot of the mould, which are afterwards exactly closed with earth, as soon as the wax is all carried off. When this is done, the whole is filled up with bricks thrown in at random, and the fire in the furnace augmented, until both the bricks and mould become red hot. The fire is then extinguished, and everything being cold again, the bricks are taken out, and their place filled up with earth, moistened, and beaten a little at the top of the mould, in order to render it the firmer. These preparatory measures being duly taken, there remains nothing but to melt the metal, and run it into the mould. This is done by means of the furnace above described, which is commonly made in the form of an oven with three apertures, one to put in the wood, another for a vent, and a third to run the metal out at. From this last aperture, which is kept very close whilst the metal is in fusion, a small tube is laid, by which the molten metal is conveyed into a large earthen basin, over the mould, into the bottom of which all the large branches of the jets or casts, which are to convey the metal into the different parts of the mould, are inserted.

These casts or jets are all terminated with a kind of plugs, which are kept close, so that, upon opening the furnace, the brass, which rushes out with violence, may not enter any of them till the basin be full enough of matter to run into them all at once; upon which occasion they pull out the plugs, which are long iron rods with a head at one end, capable of filling the whole diameter of each tube. The whole of the furnace is then opened with a long piece of iron fitted at the end of each pole, and the mould filled in an instant. This completes the work in relation to the casting part; the rest is the sculptor's or carver's business, who taking the figure out of the mould and earth with which it is encompassed, saws off the jets with which it appears covered over, and finishes it with chisels, gravers, puncheons, and other instruments. See also CASTING.

FOUNDERY of Bells. The metal for casting bells, it is to be observed, is different from that employed for casting statues; there being no tin in the statue metal, whereas in the bell metal there is a fifth, and sometimes more.

The dimensions of the core and the wax for bells, especially a chime, are not left to chance, but must be measured upon a scale, or diapason, which gives the height, the aperture, and the thickness, necessary for the several tones required. It is on the wax that the several mouldings and other ornaments and inscriptions, to be represented in relief on the outside of the bell, are formed. The clapper or tongue is not properly part of the bell, but is furnished from other hands. In Europe it is usually of iron, with a large knob at the extremity; and is suspended in the middle of the bell. In China a wooden mallet is used, which is struck by the hand against the bell; and hence the Chinese bells can have comparatively little resonance. The Chinese have a method of increasing the sound of their bells, by leaving a hole under the cannon; but this our bell-founders would reckon a defect.

The proportions of our bells differ very much from those of the Chinese. In ours, the modern proportions are, to make the diameter fifteen times the thickness of the brim, and the height twelve times. The parts of a bell are, first, the sounding bow, terminated by an inferior circle, which grows thinner and thinner; secondly, the brim, or that part of a bell whereon the clapper strikes, and which is thicker than the rest; thirdly, the outward sinking of the middle of the bell, or the point under which it grows wider to the brim; fourthly, the waist or furniture, and the part that grows wider and thicker quite to the brim; fifthly the upper vase, or that part which is above the waist; sixthly, the pallet, which supports the staple of the clapper within; and, seventhly, the bent and hollowed branches of metal uniting with the cannons, to receive the iron keys, by which the bell is hung up to the beam, and which forms its support and counterpoise when rung out.

Without entering into the details of the operations, we may state, that the business of bell-foundery is reducible to three heads; first, the proportion of a bell; secondly, the forming of the mould; and, thirdly, the melting of the metal.

FOUNDERY of Cannon, &c. See CANNON-MAKING.

Letter-FOUNDERY, or *Casting of Printing Letters.* See TYPE-MAKING, and PRINTING.

FOUNDLING HOSPITALS are charitable institutions established in most large towns in Europe, for the reception of children exposed or deserted by their parents. The exposing of children was a common practice among the nations of antiquity; for notwithstanding that infanticide might be practised with impunity, yet natural feeling would prompt parents to expose their children rather than become the immediate instrument of their death. For this purpose they generally selected such places as were much frequented, where there was a chance of their attracting the notice of the benevolent. In Athens and Rome there were places set apart for the purpose. The children so found were declared to be the slaves or absolute property of those by whom they were reared. Some of these were saved from death, not from humane motives, but that their foster-fathers might, by mutilating their persons, and exhibiting them in the streets, obtain an infamous livelihood from the alms given them by passers-by. This detestable practice seems to have been carried on pretty extensively and it is even

vindicated by Seneca, upon the ground of their being slaves. "*Gallio fecit illam questionem:—An in expositis lædi possit respublica? Non potest, inquit. An lædi possit in aliquâ suâ parte? Hæc nulla reipublicæ pars est; non in censu illos invenies, non in testamentis.*" (*Senecæ Controvers.*, v. 33.) In the fourth century the exposure of children was prohibited by Valentinian, Valens, and Gratian; but the edicts of these emperors were only partially effective, the slavery of these unfortunates continuing till the year 530, when it was abolished by Justinian. Even in ancient times the state made provision for the preservation of foundlings; but the institution of *foundling hospitals* is of later date. The first distinct trace of an express foundation of this kind is at Milan, in 787. In the year 1198, Innocent III. allotted a part of the great hospital of Spirito Santo at Rome to the reception of foundlings; and with a view to prevent the crime of infanticide, by affording persons every facility for depositing their illegitimate children without the risk of being recognized, there was fixed in the wall of the hospital a turning-box, in which the infant was placed, and taken in upon a signal being given by ringing a bell. The same secret mode of admission was afterwards adopted in many similar institutions on the Continent, and at a later period in those of London and Dublin. This facility of disposing of children led, as might have been foreseen, to very great abuses; since any woman, of whatever rank, might thus avoid the stigma of appearing as the mother of an illegitimate child; and unnatural parents, rich or poor, could avoid the expense and trouble of rearing their own children. This system has been said to find favour in some countries on account of the numbers it furnishes for the military service. The great foundling hospital of Paris was established in 1620, and up to the year 1807 had received 464,628 children. The number of foundlings in France in 1784 amounted to 40,000; in 1798 to more than 51,000; and in 1822 to 138,500. In 1847, out of 918,581 children born in France, the illegitimate births amounted to 65,626, and the foundlings to 27,284. The proportion of illegitimate children in Paris is one in every three births; and of the total number of illegitimate children, about 58 out of every 100 become inmates of the foundling hospital, where nearly two-thirds of them die before they are a year old. (See Guerry, *Statistique Morale de la France;* and Benoiston de Châteauneuf, *Considérations sur les Enfans-trouvés dans les Principaux états de l'Europe.*) According to the *Annuaire du Bureau des Longitudes* for 1855, the total number of births in Paris in 1853 was 34,049, of which 10,833 were illegitimate.

The mortality in foundling hospitals has always been very large, though this evil has been greatly mitigated by improved management, and the practice of giving out the children to be nursed. Our own country, when such institutions existed in their original form, was no exception to this reproach; for about the middle of last century, out of 14,934 children received into the London Foundling Hospital during a period of rather less than four years, only 4400 lived to be apprenticed to trades; and in that of Dublin the mortality during the six years ending 1797, was probably unparalleled by any other institution of the kind. The Foundling Hospital of London was founded in 1739; but it was soon discovered that the funds of the institution were quite inadequate for its support, so great was the influx of inmates; and in consequence of the enormous abuses to which the facility of admission rendered the system liable, it became necessary to modify the character of the institution, or rather to convert it into a kind of orphan asylum. In 1760 a total change was effected in its constitution by authority of the legislature, and it then ceased to be a receptacle for foundlings. No child whose mother does not personally appear, and who cannot satisfactorily answer the questions put to her, is received: if, however, the mother can show that she had previously borne a good character, and that, owing to the desertion of the father, she is unable to maintain the child, it is admitted, but not otherwise.

The arguments for and against foundling hospitals are very nicely balanced, and the problem is one that is extremely difficult to solve. On the one hand it is undeniable that they render the crime of infanticide and abortion less frequent, and that in the majority of cases the children are better nursed and educated than they could be at home by bad parents and bad nurses; while, on the other hand, it is objected that such institutions powerfully contribute to the corruption of morals. It seems to be the prevailing opinion in this country, that the influence of these establishments has been on the whole more pernicious than beneficial; that they have rarely accomplished their object; but that instead of preventing crime, they scatter its seeds and spread its roots on all sides. (See M'Culloch's *Principles of Political Economy.*)

FOUNT, or Font, among printers, a set of characters or letters of each kind, cast by a letter-founder, and sorted. A complete font includes the running letters, large and small capitals, single letters, double letters, points, commas, lines, and numeral characters in their established proportions, according to the language. See Type-Founding, and Printing.

FOUNTAIN, a spring or source of water rising out of the earth. Among the ancients, fountains generally were esteemed sacred; but some more especially so than others. The good effects resulting from cold bathing appears to have given rise to the belief that springs and rivers derived their salutary influence from some presiding deity. It was customary to throw little pieces of money into springs, lakes, or rivers, in order to render the presiding divinities propitious; as the touch of a naked body was supposed to pollute their hallowed waters. For the phenomena, theory, and origin of fountains or springs, see Physical Geography; Springs; Artesian Wells; and General Index.

Artificial fountains, of which there are various kinds, are all formed by pressure of some kind or other upon the water, viz., by the pressure or weight of a head of water, or by the pressure arising from the spring and elasticity of condensed air.

Fountain-Tree, or *Til-Tree*, a very extraordinary tree said to have existed formerly in the island of Hierro, one of the Canaries, and to have distilled water from its leaves in such abundance as to satisfy the requirements of those who lived near it. Whether such a tree ever existed is questionable; yet various writers have mentioned the fountain-tree of Hierro in apparently good faith. Glasse, in his *History of the Canary Islands*, published at London in 1764, alludes to it in the following terms:—"Many writers have made mention of this famous tree, some in such a manner as to make it appear miraculous; others again deny the existence of any such tree, among whom is Father Feyjoo, a modern Spanish author, in his *Teatro Critico.* But he, and those who agree with him in this matter, are as much mistaken as those who would make it appear to be miraculous. This is the only island of all the Canaries which I have not been in; but I have sailed with natives of Hierro, who, when questioned about the existence of this tree, answered in the affirmative."

FOUR BOROUGHS' COURT, an ancient Scottish court, so called because composed of delegates from four royal burghs; originally the burghs of Edinburgh, Stirling, Berwick, and Roxburgh; but from the year 1348, when the last two burghs were in the hands of the English, the burghs of Edinburgh, Stirling, Lanark, and Linlithgow. These delegates were assembled yearly at Haddington, before the Lord Chamberlain of Scotland, and formed for appeals from the burgh courts and chamberlain ayres, a court which was to the inhabitants of the burghs what the high

court of parliament was to the other inhabitants of the kingdom, the highest and ultimate court of appeal.

In 1405, when the regent, Robert Duke of Albany, uncle to King James I., was lord chamberlain, a court of the four burghs was held at Stirling, where it was resolved that deputies from the royal burghs south of the Spey should convene yearly with the four burghs, to consider and conclude on all matters affecting the common weal of all the royal burghs. This convention, though at first assembled with the court of four burghs, does not appear to have ever formed a constituent part of the latter assembly, and it seems also soon to have disregarded both the place and time of its meeting; for in 1487 its constitution was materially improved, representatives from all the royal burghs, "baith south and north," being by a statute of that year appointed to meet in convention yearly at Inverkeithing, "there to commoun and treate upon the weilfare of merchandice, the gude rule and statutes for the common profite of burrowes, and to provide for remeid upon the skaith and injuries sustained within the burrowes."

The chamberlain ayres, which had long been regarded by the nation as a grievance demanding immediate reformation, were thus substantially superseded, and accordingly soon afterwards fell into disuse. The court of four boroughs continued somewhat longer; but on the institution of the Court of Session, which was vested with a universal civil jurisdiction, its judicial functions were swallowed up, and it likewise expired. The office of lord chamberlain itself also, falling into the hands of the nobility and court favourites, ceased to be exercised; and his place in the convention came to be occupied by the Lord Provost of Edinburgh, who, though not a member, is the constant preses of the convention. The origin of this last circumstance, hitherto, we believe, unexplained by our writers, seems to be this. The convention was, by the statute above-mentioned, appointed to meet at Inverkeithing. This, however, it did not long continue to do; but, like the Court of Four Boroughs and the other supreme courts of the kingdom, removed to Edinburgh as early as the time of Alexander Lord Home, who was great chamberlain from 1488 to 1517; and as that gentleman was at one time both lord provost of Edinburgh and great chamberlain of Scotland, and also, as it seems, the last in the latter office who exercised its duties in person, hence, no doubt, arose the practice of the lord provost of Edinburgh being the permanent preses, and the town-clerk of Edinburgh the perpetual clerk, of the convention. This civic parliament has continued till the present time. By stat. 1607, c. 6, letters of horning were allowed to issue on all its acts and decrees betwixt burgh and burgh, and burgesses of free burghs, on a simple charge of ten days.

FOURCHAMBAULT, a hamlet in France, department of Nièvre, and commune of Garchizy. Its extensive iron-works give employment to about 3000 hands.

FOURCHE, Bayon la, a river of the United States, in the state of Louisiana, and one of the numerous arms into which the Mississippi divides itself in the lower part of its course. Near Donaldsonville it separates from the Mississippi in the parish of Ascension, runs through that of Assumption, forms the boundary between the parishes of Terrebonne and Lafourche Intérieure, and, after a S.E. course of nearly 120 miles, falls into the Gulf of Mexico, east of the Bay of Timballier.

Fourche Grande, a river of Lower Canada, which runs through the Côte-de-la-grande-Fourche across the Temisconata Portage into the N.W. branch of the river Troispistoles.—Fourche Petite, a river, also in Lower Canada, which issues from Lake Dessangues; it also crosses Temisconata Portage, and flows into the S.W. branch of the same river, Troispistoles.

FOURCROY, Antony Francis de, a celebrated chemist and physician, born at Paris on the 15th June 1755, was the son of John Michael de Fourcroy, by his marriage with Jane Laugier. His family had been long established in the capital; several of them had been distinguished at the bar, and Fourcroy de Ramcourt was well known as an engineer of considerable talent, and a member of the Academy of Sciences.

His father was an apothecary attached to the household of the Duke of Orleans, and was a great sufferer by the abolition of places of this kind, which was procured by the corporation of apothecaries, some time before the Revolution. Young Fourcroy was sent to the college of Harcourt, but made no progress in his learning there, and underwent great hardships, from the cruelty of an unjust master. He was afterwards obliged to subsist by his labour in copying, and by taking pupils as a writing master. He was, however, fortunate in the patronage and assistance of Vicq d'Azyr, who had been a friend of his father, and under whose auspices he resolved to study physic; obtaining his support in the mean time by giving his assistance to richer persons than himself in their literary labours, and by a few translations, for which he was very ill paid. When he had gone through the regular course of study, he became a candidate for a gratuitous diploma, upon a foundation established by Dr Diest; but he failed of success, from a party quarrel. His own party, however, which was that of Vicq d'Azyr, indemnified him for the loss, by making a collection to discharge the fees, amounting to about L.250; but the highest degree, that of doctor regent, was still refused him; and he was therefore incapable of holding a professorship under the Parisian faculty of physic. He resolved to apply himself to science as the readiest way of acquiring medical reputation; but he seems to have been little known, at any time of his life, as a practical physician. The determination, however, like that of the countryman in the fable, was still a beneficial one; and though he failed of discovering the golden treasure for which he dug, he profited by the increased fertility of the soil, and by the abundant fruits which it bore him.

In natural history he soon distinguished himself as a pupil worthy of Geoffroy, by an entomological publication; and in anatomy, by his description of the tendons and their sheaths, which appears to have procured his admission into the Academy of Sciences in 1785. He stood at first in the capacity of an anatomist, though he was afterwards removed to the section of chemistry. His favourite pursuit, however, from the beginning, was chemistry; and in this he derived considerable assistance from Bucquet, who was then a professor in great esteem; and having once undertaken to deliver a lecture in his place, on occasion of a temporary indisposition of Bucquet, though wholly unprepared, he found himself capable of speaking for two hours with great fluency, to the delight and astonishment of his audience. The reputation of Bucquet was soon transferred to Fourcroy; and he was enabled, by an advantageous marriage, to purchase the apparatus of his predecessor, and to succeed to his lectures.

In 1784, upon the death of Macquer, then professor of chemistry in the Royal Garden, the Count de Buffon found the claims of Fourcroy so strong, that he thought it right to appoint him to the vacant chair, though no less a chemist than Lavoisier was a rival candidate; the competition not being wholly decided either by talent or by depth of learning, but probably, in a great measure, by the reputation in the art of teaching which Fourcroy had already acquired. His success in this new situation was brilliant and universal; and he continued for twenty-five years to absorb the whole attention of a numerous au-

dience, by his eloquence, and by the perspicuity of his mode of explaining some of the most important novelties that have ever appeared in any age. The science which he taught was then making its most rapid progress. It was then that Bergman and Scheele had introduced into analytical chemistry a precision almost geometrical; that Priestley had discovered the aëriform elements of the animal and vegetable world; that Black and Wilcke had methodised the phenomena of heat; that Cavendish had discovered the composition of water and of the nitric acid; that Monge had repeated and extended his experiments; and that Lavoisier had reduced the whole of chemistry to a uniform system, which, though founded on a generalization somewhat too hasty, has still been of important service to the science, by concentrating the attention of the philosophic reasoner on various classes of phenomena, which could not so easily have been comprehended in one view, without the aid of some such hypothesis. M. de Fourcroy was particularly happy in his tact of perceiving whether or not all his audience were fully in possession of the ideas he wished to communicate to them, and he was never tired of explaining himself, till he was satisfied that he had said enough. His manner was energetic, and such as an Englishman might perhaps have thought pompous and affected; but we must recollect that there is no fixed standard of propriety in matters of taste, and that, as the common conversation of the French is naturally accompanied with more of emphasis and gesture than our own, it is very possible that, without any greater proportional exaggeration than is introduced in similar cases in Great Britain, an actor, a lecturer, or a preacher, may exhibit what to us would appear a caricature, while it only affects his own countrymen as a natural, though impressive, style of public speaking. The chemical amphitheatre of the Public Garden was crowded by students from all countries, and from all quarters of the globe, some prompted to visit Paris by their own love of learning only, some assisted in their pursuits by their respective governments; and it was twice in succession necessary to provide more extensive accommodations for the overflowing numbers that sought for admittance.

M. de Fourcroy's political life, though not unsuccessful, seems to have contributed less materially to his happiness than his scientific career. He was chosen a supplementary member of the National Convention, and entered on the functions of the office in the dreadful period of 1793. He had, however, the wisdom to refrain from employing the eloquence that he possessed under circumstances so dangerous, and he almost entirely confined his exertions to some attempts to soften the cruel tyranny of the times. Darcet was one of the destined victims that he had the good fortune to save; but he soon found it too dangerous to persist in such interferences. M. Cuvier, however, very fully acquits him of any approbation of the judicial murders which were committed, and of any connivance at such proceedings as it might have been possible for him to avert; declaring, that if, upon the strictest inquiry, he could have discovered that there was the least foundation for charging him with having been indifferent to the fate of his great rival Lavoisier, no consideration on earth could have induced him to become the biographer of a person so odious and contemptible. It was at a later period that Fourcroy acquired some little influence as a director of the public instruction; and in this capacity he had great scope for the exertion of his talents, in the re-establishment of the many public institutions connected with science, which the madness of the Revolution had destroyed. The *Ecole de Médécine* was one of the first that was restored; but the name of Médécine seeming to carry with it too much of respect and authority for the levelling spirit of the day, the new institution was at first called *Ecole de Santé*. M. de Fourcroy was also very essentially concerned in the organization of the *Ecole Polytechnique*, as well as of the central schools of the departments, and of the *Normal* schools of Paris; nor was he an indifferent spectator of the establishment of the *Institute*, which was at first intended to be as much immediately subservient to public instruction, as to making known the results of private study. He had also considerable influence in obtaining the adoption of a law calculated greatly to facilitate the formation of a museum of natural history on a magnificent scale. If, in the pursuit of these objects, he sometimes appeared to forget the dignity of language most appropriate to his subject, it must be remembered that he lived in times when the choice of expressions was by no means at the option of the speaker. He was once denounced by the Jacobins, merely for his silence in the assembly; but he excused himself, by pleading the absolute necessity of applying himself to chemical pursuits for the support of his family.

In 1798 his duties as a senator were terminated; but he was made a counsellor of state under the consular government, and again employed in the department of public instruction, with less liberty to pursue his own ideas than before, but with more effectual means of attaining the objects of his appointment. In this capacity he directed, in the course of five years, the establishment of twelve schools of law, and of more than thirty lyceums, afterwards called royal colleges, and three hundred elementary schools; exhibiting, in the performance of this laborious duty, the greatest possible judgment and attention in overcoming the local difficulties which perpetually occurred in the details of the undertaking, and depending on none but himself for the whole of the required arrangements. He conducted himself with great impartiality in his choice of the persons to be employed, though he sometimes found himself obliged to pay a certain degree of deference to the arbitrary power under which he acted, or even to his own political connexions. Remembering the difficulties which he had himself encountered in the early part of his career, he was particularly kind and benevolent in his intercourse with those young men to whom he was the dispenser of public munificence, in admitting them to a gratuitous education.

The great number and extent of M. de Fourcroy's scientific labours may be considered as paramount to a more immediate participation in the discovery of some of the new facts which changed the aspect of the science of chemistry. His ideas were, however, often rather enlarged than profound; and he was not uncommonly somewhat too precipitate in his conclusions; but he was generally methodical in the mode of conducting his researches, and clear in relating their results. His pursuits and projects were sometimes varied a little capriciously, though he prosecuted them all with equal warmth and eloquence. He was too much the slave of public opinion for his own comfort; and even the slightest expression of censure that occurred in private society, or the most unimportant criticism that appeared in a periodical work, became a heavy misfortune to him, and deprived him of his tranquillity for a considerable time. But the desire of universal approbation acted upon him as a strong incentive to continued exertion; and, amongst all his political and official labours, he continued his experiments, his memoirs, and his lectures, with as much eagerness as if they had constituted his whole occupation. His nerves seem ultimately to have suffered by his unremitting application, and he became subject to palpitations, which, as he was well aware, rendered the duration of his life extremely preca-

rious. At last, on the 16th of December 1809, at the age of fifty-four, as he was signing some dispatches, he exclaimed suddenly, "I am dead;" and his words were true. It happened, that on that day his family were about to assemble for the celebration of an anniversary in which they were particularly interested; the assembly actually met, though only to mourn his loss; and their disappointment was rendered the greater, upon the receipt of some distinguished marks of the imperial favour, which arrived too late to be of any use to his spirits or to his health, but which would have been of the more value to him, as he had before been passed over, when some of his colleagues had received considerable gratifications. He had, however, been made a count of the empire, and a commander of the legion of honour, in addition to his various literary and scientific titles; and he must have had the heartfelt satisfaction of reflecting, that he had been of use to the promotion of knowledge by his experiments and his writings; to his country by the public institutions which he had established; and to many deserving individuals by the benefits which he had bestowed on them, without the remorse of having done injury to any one.

He left a son by his first marriage with Mlle. Bettinger, the Count de Fourcroy, an officer of artillery, who was afterwards killed in the campaign of 1813 in Saxony, and a daughter, Mad. Foucaud. By his second marriage with Mad. Belleville, the widow of M. de Wailly, he had no children. His two maiden sisters also survived him, though by no means in a state of affluence; but they received great kindness from his friend and assistant M. Vauquelin. His place at the Institute was very ably filled by M. Thénard; M. Laugier succeeded him at the Museum, and M. Gay Lussac at the Ecole Polytechnique.

The chief of M. de Fourcroy's separate publications are, *Essai sur les Maladies des Artisans*, 12. Paris, 1777, translated from Ramazzini. *Analyse Chimique de l'Eau Sulfureuse d'Enghien*, par Fourcroy et Laporte, 8vo, 1778. *Leçons Elémentaires d'Histoire Naturelle de Chimie*, 2 vols. 8vo, 1782; 5 vols. 8vo, 1789, 1794; translated by Nicholson. *Mémoires et Observations de Chimie*, 8vo, 1784; intended as a sequel to the elements. Most of these had been read to the academy before the author was a member. They relate to the metallic carbonates, to detonations, to tests for water, to combustions in a stream of oxygen, and to the properties of several saline and metallic substances. An edition of the *Entomologia Parisiensis of Geoffroy*, 2 vols. 12mo, 1780; extracted from Geoffroy's larger work, with the addition of 250 new species. *L'Art de connaitre et d'employer les Médicamens dans les Maladies*, 2 vols. 8vo, 1785. *Méthode de Nomenclature Chimique*, par de Morveau, Lavoisier, Berthollet, et De Fourcroy, 8vo, 1787. *Essai sur le Phlogistique et les Acides*, 8vo, 1788; from the English of Kirwan. *La Médécine éclairée par les Sciences Physiques*, 4 vols. 8vo, 1791, 1792; a collection of papers, with some original essays. *Philosophie Chimique, ou Vérités Fondamentales de la Chimie Moderne*, 1792, 1796, 1800. Reviewed by Deyeux, *Ann. de Chim.* lvi.; a work which has been translated into almost every European language, including modern Greek. *Procédés pour extraire la Soude du Sel Marin*, 4to, 1795. *Système de Connaisances Chimiques*, 10 vols. 8vo, 5 vols. 4to, 1800. *Rev. Ann. Ch.* xxxvi. xxxvii. Translated by Nicholson. *Tableaux Synoptiques de Chimie*, fol. 1800, 1805. *Abrégé de Chimie, pour l'usage des écoles vétérinaires. Chimie pour les Dames*, in the *Bibliothèque des Dames*.

Besides his separate works, Fourcroy was the author of more than 160 memoirs, printed in different publications, the principal of which it will be sufficient to enumerate in a very cursory manner. The most important of his later researches were published jointly in his own name and in that of his pupil Vauquelin; and it is supposed that the processes were generally conducted and often suggested by Vauquelin, but that the investigations were set on foot and directed, and the results described and methodized, with inferences and theoretical reasoning, by Fourcroy.

In the *Memoirs of the Academy of Sciences* we find an *Anatomical History of the Tendons and their Mucous Capsules*, 1785, 1786, 1787. *On the Smoking Oil of Vitriol of Saxony, and the Concrete Salt obtained from it*, 1785; modifications of the sulphurous acid. *On Hepatic Gas*, 1786. *Report on a Sand from Peru containing Copper. On Azote, and its production in animals*, 1787. *On detecting Lead in Wines*, 1787. *On Combustions in the Oxymuriatic Acid*, 1788. *On Metals precipitated by Ammonia*, 1788. *Experiments on Animal Substances, made at the Lyceum*, 1789. *On a Liver changed by putrefaction*, 1789. *On the Colours derived by Vegetables from Oxygen*, 1789. *On an Ore of Lead from Roziers*, 1789. *On the Sulphate of Mercury, and on Triple Ammoniacal Salts*, 1790. *On the Formation of the Nitric Acid by the Action of the Oxyd of Mercury on Ammonia*, 1790. *On the Combustion of Hydrogen in close vessels*, by Fourcroy, Vauquelin, and Séguin, 1790. *On Barita and Strontia*, Mém. Inst. vol. ii. 1797. *On Phosphate of Lime and on Phosphorus*, ib. *On the Urinary Secretion in Horses and in the Human Subject*, ib. *On Urinary Calculi, with two more Memoirs on the Secretion*, iv. 1803. *On the Nitrous Oxyd*, by Fourcroy, Vauquelin, and Thénard, vi. 1806. *On Cow's Milk*, ib. *On Guano, used as a Manure*, ib. *On Tabasheer*, ib. *On the Chemical Nature of Carious Wheat*, ib. *On a Detonating Substance obtained from Indigo*, ib. *On Animal Substances treated by Nitric Acid*, ib. *Two Memoirs on Crude Platina and a new Metal found with it. On the effects of Germination and Fermentation on Corn and Pulse*, vii. 1801. In the *Memoirs of the Royal Society of Medicine for* 1782–83–84, Par. 1787, we find a valuable memoir *On the Muriate of Lime*, p. 267. *On Morbid Changes in some of the Animal Fluids*, p. 488. *On the Nature of Muscular Fibres, and on the Seat of Irritability*; showing the analogy of muscular fibre to the coagulable lymph of the blood.

Many of these earlier papers have also been printed in the *Annales de Chimie*, but they are sometimes altered, and they are mixed with others which are original. *On Azote* (20), vol. i. (1789). This memoir exhibits no very favourable specimen of the author's accuracy; for he asserts in it that pure azote turns vegetable blues to green, and that it may be obtained, by means of a low heat, from the oxide of manganese. *On the Gas in the Air Vessels of the Carp. On a Morbid Change in the Blood*, ib.; exuding from the face. *On detecting Lead in Wine* (21), ib. *On two Ores of Lead*, ii. *On the action of Oxyds on Ammonia*, ib. *On the Salts of Magnesia*, ib. *On a Change in the Liver after Death* (25), iii. *On Biliary Calculi*, ib.; describing the adipocere of these substances. *On the Albumen of Vegetables*, ib. *On the Carbonate of Barita of Alston Moor*, iv. *On the Medical Properties of Oxygen*, ib. *On the Triple Salts of Ammonia and Magnesia*, ib.; an elaborate and interesting paper. *On Combustions in Oxymuriatic Acid Gas*, ib. *On the effect of Oxygen in colouring Vegetables, and on the preparation of Solid Pigments*, v. *On the Changes observed in the Cemetery of the Innocents*, ib. Fourcroy had observed that the muscular parts were often changed into a substance resembling spermaceti. *On a Black Sand from St Domingo*, vi. *On the Water of Enghein*, (2), ib. *Discoveries in Animal and Vegetable Chemistry*, ib. *On the Formation of the Nitric Acid from the Action of the Oxyd of Mercury on Ammonia*, ib. *On the Culture of Cloves in the Isle of Bourbon*, vii. *Experiments on Animal Substances made at the Lyceum in* 1790, (24), ib. *Second Memoir on the Substances found in the Cemetery. On the Cinchona of St Domingo*, viii. x.; *On the Combustion of Hydrogen*, (30), viii. *Report on Loyser's Art de la Verrerie*, ix. *On Bell Metal*, ib. The principal object of this paper is to discover a ready mode of converting the spoils of the churches into copper coin. *On Tears and Mucus*, x. *On the Sulphate of Mercury, and its combination with Ammonia*, ib.; *On the Refinement of Saltpetre*, xi. *On the Juice which furnishes Elastic Gum*, ib. *Note on the Decomposition of the Carbonic Acid Gas, effected by Mr Tennant*, xii. *On Triple Salts*, xiii. *On Animal Concretions*, from the *Dictionnaire Encyclopédique*. *On the Brain*, xvi. *Report on some Artificial Pencils*, xx. *Extract of a Memoir on Hydrocarbonous Gas, and on the supposed Combustion of Azote*, xxi. *On Detonations by Percussion*, ib. *Extract of a Memoir of Proust on Odoriferous Substances*, ib. *On obtaining Pure Barita*, ib.; an elegant and effectual process. *On the Union of Chemistry with Pharmacy*, ib. *On Vitality, and on Humboldt's Experiments*, xxii. *On the Action of the Sulphuric Acid on Vegetable and Animal Substances*, xxiii. *On the Formation of the Sulphuric Ether*, ib. *On the Sulphurous Acid*, xxiv. *Report on some Colours for Porcelain*, xxv. *Letter to Humboldt on the Chemistry of Life*, xxvii. *Examination of Dr Pearson's Experiments on Calculi*, ib. *On Pneumatic Medicine*, xxviii. *On the Experiments of Mayow*, from the *Dictionnaire Encyclopédique*, xxix. *Novelties from Egypt*, ib. *On Congelation by Artificial Cold*, ib. *Letter to Giobert on Calculi*, xxx. *Notice of Venténat's Vegetable System*, ib. *On the Chemical and Medical History of the Urinary Secretion*, xxxi. xxxii. His investigations respecting calculi, however, notwithstanding their importance, were in a great measure anticipated by Wollaston, whose paper, however, is not mentioned by M. de Fourcroy. *Notice of the Chimie Optematique*, xxxi. *Account of a Memoir of Fabroni on Fermentation and on Ether*, ib. *Chemical Novelties*, xxxii. *Report on Paul's Artificial Waters*, xxxiii. *On Dabit's Ether*, xxxiv. *On the Identity of the Three Empyreumatic Acids with the Acetic*, xxxv.; suggesting that they might be substituted for it in some economical processes. *Galvanic Experiments*, xxxix; by Fourcroy, Vauquelin, and Thénard. *Note in Answer to Proust*, xlii. *Remarks on a Memoir of the Dutch Chemists on the Carbonic Oxide*, xliii. *On a New Phosphate*

found in the Bones, xlvii.; that of magnesia, not before observed. *Extract of a Memoir on Platina*, xlviii. *Two Memoirs on Crude Platina, and on a Metal found with it*, xlix. l. *Extract from Izarn's Manual of Galvanism*, l. *On the Alumina of Saxony*, lii. *On a Fluid found in the Caoutchouc of the Castilloya Elastica*, lv. *On a Denonating Substance formed by the Action of the Nitric Acid on Indigo and Animal Matters*, lv.; the investigations relating to indigo have since been carried further by Mr Hatchett. *On the Products of Animal Substances treated with the Nitric Acid.* lvi. *On the Guano* (39), lvi. *Experiments on Ivory, Recent and Fossil, and on the Enamel of the Teeth, in search of the Fluoric Acid*, lvii.; these experiments were not completely successful, though the fluoric acid had been detected by Morichini in the teeth before that time, and by Berzelius more recently.

M. de Fourcroy was for some years the editor of the *Journal des Pharmaciens*; he first suggested the idea of the publication of the *Annales du Muséum d'Histoire Naturelle*, and contributed several valuable papers to it, as well as to the *Journal de l'Ecole Polytechnique*, and to the *Magazin Encyclopédique*. He was also the author of some very voluminous articles in the chemical part of the *Encyclopédie Methodique*; but the fabric of his celebrity is principally founded on the works which have already been enumerated.

(Palissot de Beauvois, *Eloge Historique*, Par. 1810; Cuvier, *Eloge*, M. Inst. A. Math. 1810, and in Biographie Universelle, xv. 8. Par. 1816; Thomson's *Annals*, i. May 1818, p. 321; Aikin's *General Biography*, vol. x. 4to, Lond. 1815.) (T. Y.)

FOURIER, Charles, the celebrated French sociologist was born at Besançon in 1772, and died at Paris in 1837. A detailed account of his life with an analysis of his doctrines is given under the article Communism, vol. vii. pp. 209-210.

FOURMONT, Etienne, professor of the Arabic and Chinese languages, and one of the most learned men of his time, was born at Herbelai, near Saint Denis, about four leagues from Paris, in 1683. He studied in Mazarin College, and afterwards in the Seminary of Thirty-three. He was at length appointed professor of Arabic in the Royal College, and admitted a member of the Academy of Inscriptions. In 1738 he was chosen a member of the Royal Society of London, and in 1741 a member of that of Berlin. He was often consulted by the Duke of Orléans, first prince of the blood, who had a particular esteem for him, and made him one of his secretaries. Fourmont was the author of many learned works, the most important of which are—*Racines de la Langue Latine mises en vers François*, Paris, 1706, in 12mo; *Réflexions Critiques sur les Histoires des Anciens Peuples*, Paris, 1735, in 2 vols. 4to; *Meditationes Sinicæ*, 1737, in folio; *Grammatica Sinica* (Chinese Grammar), 1742; and several Dissertations printed in the *Mémoires de l'Acad. des Inscriptions*. Fourmont died at Paris on the 18th December 1745, at the age of sixty-two. He must not be confounded with *Michel Fourmont*, his youngest brother, who was professor of the Syriac language in the Royal College, and a member of the Academy of Inscriptions, and who died in 1746.

FOURNESS, or Furness, a tract of land in Lancashire. See Lancashire.

FOU TCHOW FOU, or Fuhchau Fu, a city of China, capital of the province of Fo-kien, and one of the five ports recently opened for commerce, stands on the N. side of the Min river, 34 miles from its mouth, and 9 from Pagoda island, where ships anchor. N. Lat. 26. 5.; E. Long. 119. 20. The walled city is about 3 miles from the river, but extensive suburbs stretch along both its banks. They are connected with each other, and with a small islet in the river by a stone bridge 420 paces long, lined with shops, and resting on solid stone piers, 40 on the northern, and 9 on the southern side. Several lookout houses are placed over the streets, or upon the roofs of buildings, one of which immediately attracts the attention of the visitor from its height, and its clock-dial with Roman characters. Few vacant spaces occur within the walls of the city, which is everywhere equally well-built. Serpentine canals divide the country around into plats of greater or less extent, and help to drain the city, as well as provide channels for boats to come up from the river. These parts of the landscape are dotted with hamlets and cottages, or, where the ground is higher, with graves and tombstones. The maritime commerce of this city is very considerable, and its manufactures of cotton goods and porcelain ware are extensive. The population of Fou Tchow Fou and suburbs, is estimated at about 600,000.

FOWEY, a decayed seaport, borough, and market-town of England, county of Cornwall, at the mouth of a small river of the same name, 11 miles S.S.E. of Bodmin. The town is surrounded by scenery of great beauty, but it is irregularly built, and the streets are very narrow and full of angles. The inhabitants are engaged chiefly in the catching and curing of pilchards. The harbour is safe and commodious, and is defended by an ancient and two modern forts. Previous to the Reform Act by which it was disfranchised, it returned two members to parliament. This town became famous in the old French wars, and in 1347 sent 37 tall ships to the siege of Calais. It was burned by the French in 1457. Pop. of parish (1851) 1606.

FOX, in *Zoology*. See index to Mammalia.

FOX, Charles James, a celebrated statesman and orator, was third son of the Right Honourable Henry Fox, afterwards Lord Holland, and of Lady Georgina Caroline Fox, eldest daughter of Charles, second Duke of Richmond. He was born on the 24th January 1749.

Mr Fox received the first rudiments of his education in a private school of some celebrity, kept by a Mr Pampelune at Wandsworth. In 1758 he was sent to Eton, where he gave early promise of future eminence. In the beginning of summer 1763 the mistaken indulgence of his father carried him first to Paris, and then to Spa. After wasting idly three months abroad, he was sent home to England, and at his own desire he went back to Eton He had left school a boy; he returned to it with all the follies and fopperies of a young man. At Spa he had been initiated in play; and his father, whose fondness for him was excessive, had encouraged him in a propensity which was the source of much future unhappiness to both.

In the autumn of 1764 he was removed from Eton and sent to Oxford, where he was placed at Hertford College, under the tuition of Dr Newcome, afterwards primate of Ireland. At Oxford as well as at Eton he distinguished himself not less by his powers of application than by the quickness and superiority of his parts. The following letter, which he preserved with care, and used to show with triumph when reproached for idleness, is a curious document of his diligence in study while he was at college. "You judge rightly," says Dr Newcome in a letter to his pupil, "in thinking that I should be much surprised by the information which you were so obliging as to give me. But, on reflection, I think you have done well to change the scene in such a manner, and I feel myself inclined to envy you the power of doing it. Application like yours requires some intermission; and you are the only person with whom I have ever had connection to whom I could say this. I expect that you will return with much keenness for Greek, and for lines and angles. As to trigonometry, it is matter of entire indifference to the other geometricians of the college (who will probably continue some time here), whether they proceed to other branches of mathematics immediately, or wait a term or two longer. You need not, therefore, interrupt your amusements with severe studies; for it is wholly unnecessary to take a step onwards without you, and therefore we shall stop till we have the pleasure of your company. All your acquaintances here whom I know are well, but not much happier for your absence." This letter was probably written in spring 1765, when Mr Fox made a second excursion to Paris with his mother.

In autumn 1766 he quitted Oxford, and accompanied

his father and mother to the south of Europe, where Lord Holland had been advised to pass the winter on account of his health. He remained with them at Naples during the winter, and not finding a good Italian master there, taught himself that language. In the following spring he attended them as far as Turin in their way to England, and then went to Genoa to meet Lord Fitzwilliam, with whom and Mr Uvedale Price he spent the summer in Italy, chiefly in Tuscany. In the beginning of winter he rejoined his father and mother at Paris, and accompanied them to Nice, where he passed with them the winter of 1767–68. It was during this long residence in Italy that he contracted his strong partiality for Italian literature. In a letter to Mr Fitzpatrick, written from Florence in September 1767, he conjures him to learn Italian as fast as he can, if it were only to read Ariosto. "There is more good poetry in Italian than in all other languages I understand put together." He appears to have indulged freely at this period in all the pleasures natural to his time of life, but never to have intermitted entirely his application to study. *Je travaille toujours le matin*, he says, in another letter written from Nice. Acting plays was also at this time one of his favourite passions, though he confesses that the last time he acted he fell far short of his own expectations; "but then," he adds, "my expectations, it must be confessed, were very high." In the course of this journey he made a visit to Voltaire at Fernay, in company with Mr Price.

He did not return to England till August 1768; and having been elected one of the burgesses for Midhurst in his absence, he took his seat in the ensuing session, and made his first speech in the House of Commons on the 15th of April 1769, in support of the decision in favour of Colonel Luttrel, on the famous Middlesex election. He spoke, says Horace Walpole, with insolence, but with infinite superiority of parts.

Lord Holland, father to Mr Fox, had begun his political career as an adherent of Sir Robert Walpole, and continued ever after one of the steadiest friends and warmest admirers of that great statesman. The treachery of the Pelhams to his patron excited an early prejudice in his mind against all the members of that family; and the falseness, folly, and fickleness of the Duke of Newcastle added contempt and distrust to his dislike. After a long rivalship with Mr Pitt, he was finally driven from the cabinet by a coalition of the Pitt and Newcastle parties, and reduced to the subordinate though lucrative employment of paymaster of the forces. In this situation he was found by Lord Bute at the conclusion of the war, and recommended to the king as the only person in the House of Commons who had courage and ability to defend the peace against Mr Pitt and the Newcastle party. It was with great difficulty he was prevailed on by his majesty to undertake this office, but when engaged in it, he performed it most successfully. For his services on this occasion he was rewarded with a peerage; but the part he had taken estranged him for ever from his old friends the Dukes of Cumberland and Devonshire, and other leaders of the Whig party. It was at this period that his son Charles received his first political impressions; and there is still extant a copy of French verses written by him in 1764, in praise of Lord Bute, and full of invective against Mr Pitt. When brought into parliament, he was, therefore, in the first instance, connected with the Duke of Grafton's administration, which, though originally formed under the auspices of Lord Chatham, had been gradually sinking into a mere court party.

Mr Fox was not of age when returned to parliament, and probably for that reason, after his first speech, he took little part in public debate till January 1770. During this interval he made another excursion to the Continent, where he is chiefly taken notice of for his losses at play. He had, as already mentioned, acquired a passion for play as early as his first journey to Spa; and for many years afterwards, when not engaged in active political business, play and Newmarket were his chief avocations. His losses were such as early to embarrass, and finally to ruin, his private fortune; but so great a hold had these pursuits taken of his mind, that, till the payment of his debts in 1794, he could never prevail on himself to renounce them entirely. From that moment he gave them up for ever.

In February 1770 he was rewarded for his support of government with the place of junior lord of the admiralty, which he retained for two years, and resigned on the 20th of February 1772, partly in consequence of some slight offence he had received from Lord North, and partly because he had resolved to oppose the royal marriage bill, "which, *in place*," he says, "I should be ashamed of doing;" but he had no thoughts, he adds, "of going into opposition." He had an immediate and satisfactory explanation with Lord North; but, to punish him for his speech against the royal marriage act, which was a measure entirely the king's own, he was suffered to remain a considerable time out of office. At length, in January 1773, he was made one of the lords of the treasury, a situation he continued to fill till his memorable quarrel with Lord North in the following year.

Some gross and scandalous reflections upon the speaker of the House of Commons, written by the celebrated Horne Tooke, having appeared in the Public Advertiser, Mr Woodfall, the printer of that newspaper, was called to the bar of the house, and having there confessed himself publisher of the libel, he was declared guilty of a breach of privilege; on which Mr Herbert moved that he should be taken into the custody of the serjeant-at-arms. The house, unwilling to engage in a fresh contest with the press and the city, were disposed to acquiesce in this motion; but Mr Fox, thinking the punishment inadequate to the offence, without consulting Lord North, moved, as an amendment, that Mr Woodfall should be committed to Newgate. Lord North found himself compelled by this motion to resist Mr Herbert's proposition; but though he substituted the Gatehouse for Newgate, as a less objectionable place of confinement, he was left in a minority on the division, the original motion being carried by a great majority. Incensed at this disgrace, and determined to punish his youthful colleague for his temerity, he had a new commission of the treasury made out a few days afterwards, in which the name of Mr Fox was omitted. This happened in February 1774.

Long before his breach with Lord North, Mr Fox had formed an intimate acquaintance with Mr Burke, one of the leading members of the Whig or Rockingham party in the House of Commons; and to the friendship he contracted with that gentleman may, in a great measure, be attributed the decided change in his political character and opinions, which commenced at this time. He had been brought up by his father in the maxims and principles of Sir Robert Walpole; and from this education he derived the love of peace, the good-humoured spirit of conciliation, and ardent attachment to civil and religious liberty, which were afterwards the most conspicuous features of his public character, and are certainly the chief merits of the Walpole school. But the tone and character of Sir Robert Walpole's policy, though suitable, and perhaps necessary, for the times in which he lived, was no longer adapted to the state of the country. When the Jacobites renounced their idol without changing their creed, and transferred to the house of Brunswick the same allegiance

which they had borne to the Stuarts, the weapons which Sir Robert had employed to preserve the constitution became, in the hands of its enemies, instruments of its destruction. Mr Burke was the first to perceive, or at least the first to explain, the change that had taken place in our internal government, and the first to point out a plan of systematic opposition in parliament, as the only means of preventing, or at least of retarding, what Mr Hume has called the *euthanasia* of English liberty. In Mr Fox he found a pupil ready to receive his lessons, and prepared by character and turn of mind to act upon them with fortitude and perseverance. From Mr Burke's example and instructions Mr Fox caught more elevated notions of public principle than had animated the successors of Sir Robert Walpole; and from the writings and conversation of the same great man he learned the necessity of party connections in a mixed government like ours, to counteract the influence of government, and preserve a due balance of power between the crown and the people. The American war roused all the energies of his mind. The discussions to which it gave rise involved all the first principles of free government. The vicissitudes of the contest tried the firmness of its opponents. Its duration exercised their perseverance. Its magnitude and the dangers of the country called forth their powers. The progress of Mr Fox was steady and uninterrupted. So early as the beginning of 1775, we are told by Gibbon that "he discovered powers for regular debate, which neither his friends hoped nor his enemies dreaded."

But, notwithstanding the brilliancy of his talents and the reputation he acquired in the House of Commons, the levity and want of decorum of his private life, the dissipation in which he indulged, and the embarrassments in which he was involved, prevented him, for some years, from obtaining the weight and consideration with opposition, due to his extraordinary abilities and exertions. So late as the beginning of 1778 he was under no engagements with any set of men; but, though not absolutely engaged in party connections with the Whigs, he had determined on no account to abandon their principles; and from a cool consideration of his own character, and a just conception of the prevailing sentiments of the country, he had already fully made up his mind to the fate that ultimately awaited him. "People flatter me," he says in a letter to Mr Fitzpatrick, written in 1778, "that I continue to gain rather than to lose character as an orator; and I am so convinced this is all I ever shall gain (unless I chuse to be one of the meanest of men), that I never think of any other object of ambition. I am certainly ambitious by nature, but I have, or think I have, totally subdued that passion. I have still as much vanity as ever, which is a happier passion by far, because great reputation, I think, I may acquire and keep; great situations I never can acquire, nor, if acquired, keep, without making sacrifices that I will never make. If I am wrong, and more sanguine people right, *tant mieux*, and I shall be as happy as they can be; but if I am right, I am sure I shall be happier for having made up my mind to my situation." He expresses great joy at the prospect of Fitzpatrick's return, who he knew would be of his opinion in certain emergencies that might arise. "I shall be told by prudent friends that I am under no sort of engagements to any set of men. I certainly am not; but there are many cases where there is no engagement, and yet it is dishonourable not to act as if there was one. But even suppose it were quite honourable, is it possible to be happy in acting with people of whom one has the worst opinion, and being on a cold footing (which must be the case) with all those whom one loves best, and with whom one passes one's life?" With these sentiments it is not to be wondered at that he rejected overtures made to him by Lord Weymouth, in summer 1778, to join administration; nor, with his powerful talents and unremitted exertions, the inflexible steadiness of his public conduct, and the unexampled force and vehemence of his eloquence, that he gradually acquired the perfect confidence of the Whigs, and came at length to be considered as the leading member of the Rockingham party in the House of Commons. It ought to be recorded to the credit of Mr Burke, that he witnessed with pleasure, unmixed with envy, the progress and elevation of his pupil, and cheerfully resigned to him the station he had so long himself occupied in the party.

The day of triumph at length arrived. A resolution against the further prosecution of the American war was carried in the House of Common. Ministers still lingered in office, but the fears of a direct vote of censure compelled them to resign. The king, whose pertinacity in support of his favourite principles of government had been the chief if not the sole cause of the apparent reluctance of his ministers to retire from office, was compelled at length to yield to the wishes of his Commons; but in the very act of forming a new administration, he contrived to sow the seeds of disunion in its bosom. The opposition to the American war had been composed of two parties, united in their disapprobation of that contest, but disagreeing on many other points of external as well as of internal policy; both calling themselves Whigs, but Whigs of different schools; the one consisting of the old Whig connection, formed and educated in the principles of Mr Burke; the other composed of the friends and followers of Lord Chatham. At the head of the first was the Marquis of Rockingham, whilst the leader of the second was the Earl of Shelburne. His majesty began by sounding Lord Rockingham, through the chancellor. The demands of Lord Rockingham were, to have full power to recognise the independence of America, and authority to bring forward, as ministerial measures in parliament, bills for reducing the influence of the crown, by abolishing offices, excluding contractors from the House of Commons, and depriving revenue officers of their votes at elections; and, with respect to reform in the representation, or limitation of the duration of parliament, he declined to lay himself under restrictions. After taking time to consider this answer, his majesty sent for Lord Shelburne, and had a conference with him at Buckingham house. Two days afterwards he sent for him again, and offered him the treasury, which his Lordship declined, saying that no administration suited to the present emergency could be formed unless Lord Rockingham was at the head of it; on which the king desired him to go to Lord Rockingham with an offer of the treasury, and to add, that he had full powers from his majesty to treat both with respect to men and measures, with one reservation only, that he should himself be one of the secretaries of state. The first impulse of Lord Rockingham was to decline this offer, upon the ground, that if it was the king's intention to place him at the head of the treasury, his majesty could have no fit objections to conversing with him on the arrangement of the administration; but his friends persuaded him to overlook that objection, lest his refusal should be ascribed to pique or jealousy, at a moment when the public was extremely impatient for the formation of a government. Many fatal consequences ensued from the negotiation taking this course and passing through the hands of Lord Shelburne. No direct communication took place between the king and the Rockingham party, who were to compose the majority of the cabinet, with respect to the measures to be pursued, till after the administration had been formed. Lord Thurlow, a decided partisan of the old system, and an enemy to every species of reform, was retained as lord

chancellor; Mr Dunning having been prevailed upon by his friend Lord Shelburne to waive his pretensions to that office. When this arrangement was communicated to Mr Fox, he told Lord Shelburne plainly, "that he perceived the administration was to consist of two parts, one belonging to the king, the other to the public." But the worst effect of all was the impression left on the mind of Lord Shelburne, that he alone possessed the confidence of his sovereign, to the exclusion of his colleagues. This persuasion bred distractions in the cabinet, which soon became a theatre of dissension and open division; and these divisions, whispered about, weakened the government whilst it lasted, and contributed materially to its fall.

Of this short-lived administration, the principal measures were the pacification of Ireland and the bills for economical and parliamentary reform, which, though short of the public expectation, are still the most important acquisitions of that description obtained since the accession of the house of Hanover. The death of Lord Rockingham dissolved the ministry over which he presided. The treasury was immediately offered to Lord Shelburne, on pretence that, having refused it before, it naturally devolved on him on Lord Rockingham's death. His acceptance of it destroyed the former balance of parties in the cabinet, and overset entirely the balance of power in the government. Accordingly Mr Fox and Lord John Cavendish immediately resigned, and, after some interval, they were followed by Lord Keppel. The Duke of Richmond and General Conway remained in office; the latter from simplicity, the former from dissatisfaction at seeing the Duke of Portland preferred to himself as leader of the Whig party. The other members of the cabinet were friends of Lord Shelburne.

Mr Fox has been severely blamed for his precipitancy on this occasion; and, though his resignation was a measure that could not long have been deferred, the time at which it took place makes it perhaps liable to that imputation. It followed so immediately the appointment of Lord Shelburne to the treasury, as to have the appearance of being the result of disappointed personal ambition, rather than of any difference on public grounds. It reduced his friends who were in office to the alternative of immediately following his example, or of passing for adherents of Lord Shelburne; and, as the whole of his motives could not at that time be explained in public, it gave an opportunity to the Duke of Richmond and others to keep their places without forfeiting their characters. It took place at the close of a session of parliament, and left Lord Shelburne and the court for six months in undisturbed possession of the government. It was a cruel disappointment to the public, which had expected a firm and united administration on the principles of those who had opposed the American war and the system that gave rise to it. But to those who judged rightly, the elevation of Lord Shelburne to the treasury was the utter extinction of these hopes. The Rockingham party had found in Lord Shelburne an active and spirited ally in opposition; but they had never been confidentially united with him; and though ready to co-operate with him in a subordinate office, they were not prepared to act under him as premier. It was not the impatience and dissatisfaction of Mr Fox alone that broke up the administration. As soon as the appointment of Lord Shelburne to the treasury was known in Dublin, the Duke of Portland determined to resign his office of lord-lieutenant of Ireland. Lord John Cavendish could with difficulty be prevailed upon to postpone his resignation for a few days. Mr Burke urged strongly to Mr Fox the impossibility of his remaining long in office as a clerk under Lord Shelburne; and it must be owned that, in the subsequent treatment of his colleagues, that nobleman fully justified the apprehensions then entertained of his future conduct. Elated with the fancied possession of court favour, he from that time forward treated the other ministers as mere ciphers; made additions to his cabinet without consulting or even apprising them of his intentions; and is even said to have settled and concluded the terms of his peace with France, without the advice or participation of his secretaries of state.

There were, besides, before the death of Lord Rockingham, differences of such importance in the cabinet as must have led to a dissolution of the administration. It was the policy of Mr Fox to detach Holland and America from their unnatural connection with France; and the great object of his foreign politics was, to form a continental alliance as a balance against the house of Bourbon. The system of Lord Shelburne was to conciliate France, to cultivate a confidential understanding with her government, and to treat her allies as so many inferior and dependent powers. Mr Fox had recommended and carried in the cabinet (23d May 1782) a resolution to instruct Mr Grenville, his majesty's plenipotentiary at Paris, to propose the independence of America in the first instance, instead of making it a condition of a general treaty; and this offer, to which his majesty's consent had been obtained, was actually communicated by Mr Grenville to Dr Franklin. Lord Shelburne, though obliged to acquiesce in the determination of the cabinet, endeavoured afterwards to represent the offer as only conditional, to be recalled if not accepted as the price of peace; and this explanation having been adopted by a majority of the cabinet after the illness of Lord Rockingham, Mr Fox declared his determination to resign. The discovery of a mysterious negotiation at Paris contributed to strengthen this resolution. It was a great object with Mr Fox, in pursuance of his system of policy, to open a free and unreserved communication with Dr Franklin. Through Mr Grenville he had hoped to accomplish this design, and he had nearly succeeded in his purpose, when he had discovered, to his infinite surprise and indignation, that Lord Shelburne had been carrying on a clandestine intercourse with Franklin through Mr Oswald, and had received from him and made to him important communications, which had not been imparted to his colleagues. This discovery, which was made before Lord Rockingham's death, destroyed all confidence in Lord Shelburne among the friends of that nobleman, though, from the delicate nature of the transaction, it was impossible at the time to make it the subject of public animadversion, or even allusion.

The resignation of Mr Fox and his friends compelled Lord Shelburne to strengthen his government from every quarter where support could be obtained. Mr Pitt, who had declined accepting a subordinate office in the Rockingham administration, became his chancellor of the exchequer. Rigby, Dundas, and Jenkinson, old supporters of the American war, attached themselves to his train. A negotiation was opened with the remaining partisans of Lord North, which only failed of success in consequence of Mr Pitt, with more judgment than feeling, making personal objections to Lord North himself, which wounded the pride, and excited the indignation, of his friends and family. When parliament met after the signing of the preliminaries of peace, there were three parties, nearly of equal strength, in the House of Commons; that of the minister, reinforced by the court, and several of the most objectionable members of Lord North's administration; the Rockingham party, who had gone into opposition with Mr Fox; and, lastly, Lord North and his friends. That three separate parties, so equally balanced, should continue to act in the House of Commons without some coalition, was not to be expected. A re-union of the

Whigs would have been most acceptable to the public; but recent differences, mutual recriminations, and distrust of Lord Shelburne, rendered such a coalition impracticable. The personal objections, so harshly and acrimoniously stated, against Lord North, had exasperated his friends against the ministry. Nothing, therefore, remained but a junction of the two parties in opposition; and this coalition, which time would naturally and imperceptibly have brought about, was hastened and matured by the coincidence of their opinions against the peace. The first step was to concert an amendment to the address of thanks on the preliminary articles signed at Versailles; and this amendment was carried in the Commons by a small majority, but not without great indignation being expressed in the house, and a violent outcry raised out of doors, at the apparent junction of the two parties. No coalition had yet taken place. Lord North was still at liberty to have formed an administration without Mr Fox; and it was the opinion of one of the most judicious friends of the latter, that to undertake the government with Lord North, "was to risk their credit with the public on very unsafe grounds." On the part of the Whigs there seems to have been a momentary hesitation whether to proceed farther or to step back. "Unless a real good government is the consequence of this junction," says one of the most sagacious of the party, "nothing can justify it to the public." "There never was a case of more difficulties and dangers to the real friends of whiggism and good principles." The die was at length cast; and in an evil hour, if we are to judge, not from principles, but from results, the coalition was effected. The united strength of the two parties procured a vote of censure on the peace. Lord Shelburne, who still flattered himself with the possession of court favour, is said to have proposed an immediate dissolution of the parliament. But he had served his turn, and was no longer wanted. His majesty judged rightly, that the time was not yet come for so bold a measure, and allowed his minister to resign.

A long interval ensued before the coalition administration was formed. Repeated attempts were made to detach Lord North from Mr Fox; and when these had failed, it was stated as an indispensable preliminary to any ministerial arrangement, that Lord Thurlow should be continued as lord high chancellor. But the fatal effects of a secret enemy in the cabinet had been too severely and too recently felt to concede a point of so much importance. A complete change of administration was insisted upon, and was granted at last, but with the worst possible grace, and with every symptom of ill humour and dissatisfaction. It was not merely the triumph of the coalition that filled the royal bosom with such indignation. His majesty considered the Rockingham party as enemies to his just prerogative. Nor could he forgive them for their zeal against the American war, and inflexibility, when they came into office, in insisting on the unconditional acknowledgment of American independence. "The extraordinary and never to be forgotten vote of February 1782, and the hurry for negotiation that after ensued," had, in his opinion, lowered the spirit of the country, and given confidence to its enemies; and in his own mind had produced such indifference on political subjects, that he felt no anxiety for the arrival of the definitive treaty, or concern for the delays that retarded its conclusion. When it was suggested to him that a wish on his part to receive a minister from America would be favourably received in that country, and might tend to preserve peace and restore harmony in future, he is said to have replied with bitterness, that to receive a minister from America, he could never say would be agreeable to him; and that he should ever have a bad opinion of any Englishman who could accept being an accredited agent to that revolted state. With such feelings rankling in his mind, is it to be wondered at that his majesty was hostile to an administration, the majority of which had zealously concurred in the grant of independence to America?

The coalition ministry was hardly settled, when a misunderstanding arose about the establishment of the Prince of Wales; and so skilfully had the affair been managed on the part of the king, that if his royal highness had not submitted entirely to his father's pleasure, the administration must have been overturned almost as soon as formed. But though no change was attempted before the meeting of parliament, his majesty contrived on every occasion to show ill humour to his ministers, and no one in a situation to observe could doubt for a moment that he only waited for a favourable opportunity to turn them out. The India bill afforded such opportunity. That measure was represented as an invasion of chartered rights, as the establishment of a ministerial oligarchy, independent both of prince and people. The nation, disgusted and offended at the coalition, listened with credulity and favour to these accusations. The king, who had carefully disguised his sentiments to the last moment, procured the rejection of the bill in the Lords, through the agency of Lord Temple, and instantly dismissed his ministers.

The coalition ministry was at an end, but its leaders still possessed the confidence of the House of Commons. The cry of secret influence was raised, and more violent addresses carried to the throne than had ever been presented to any prince of the house of Brunswick. Lord Temple, who had accepted the seals, grew frightened at the storm he had raised, and gave in his resignation. Even Mr Pitt became alarmed in the progress of the contest; and the firmness of the Duke of Richmond alone prevented him from following the example of his kinsman. But, as the struggle proceeded, the voice of the people was every day more unequivocally declared in support of the new administration. Courtiers and reformers, churchmen and dissenters, squires and nabobs, joined in execrating the coalition and applauding the minister, in professions of attachment to the king, and declarations of hostility to the Commons. After the attempt of the country gentlemen to make a new coalition of parties had failed, the majorities of opposition began to diminish; and when some necessary votes had been obtained, this refractory House of Commons was punished by a premature dissolution, for its want of subserviency to the crown.

Our limits will not permit us to follow with the same minuteness the political life of Mr Fox in the subsequent parts of his public career. From 1784 to 1792 he was leader of a powerful party in the House of Commons, in opposition to Mr Pitt. His most remarkable exertions during that period were against the Westminster scrutiny, on the regency, against the abatement of impeachments by a dissolution of parliament, on the libel bill, and on the Russian armament. He never published nor corrected any of his speeches, except the one on moving a new writ for the borough of Tavistock; and of those which appeared in the newspapers, and have since been collected, his speech on the scrutiny is the only one so well reported as to give the reader an adequate notion of his style of speaking. It failed at the moment in procuring justice for the Westminster electors; but the impression it made on the house was such, that in the following year an end was put to that odious and vexatious piece of chicanery, worthy of the pettyfogging genius of its inventor, but disgraceful to the minister who gave it his countenance and support. We have not room to discuss at length the regency question. The case was new and unprovided for.

There was no direct precedent, nor legal authority in the kingdom to make one. Constitutional analogy pointed out the heir-apparent as the fittest person to exercise the royal authority during the indisposition of the king; and the same analogy indicated the great council of the realm as the body most competent to declare the incapacity and apply the proper remedy. Strict or legal right there was none on either side. The prince had no legal right to the regency; nor till they chose to declare it themselves, had the two houses of parliament any legal right to elect a regent, or to fetter him, previous to his election, with restrictions. The contrivance to create, first a phantom, and then a regent, was a clumsy piece of machinery, nearly allied to treason. The claim of right advanced for the prince was a flimsy speculation of Lord Loughborough, adopted on his authority, without due examination, by Mr Fox, who returned in haste from Italy, while the discussions on the regency were pending. As explained afterwards, the doctrine, if not true, was at least harmless. But the opportunity was skilfully laid hold of by the minister, for the purpose of making his rival unpopular, and of gaining time for the king's recovery, which Addington, who had great experience in such maladies, assured him, from the beginning, would certainly take place. In his argument against the abatement of impeachment by a dissolution of parliament, Mr Fox had the support of Mr Pitt, and never was a more triumphant reply than his answer to the arguments on the other side. Of the libel bill it is unnecessary to say a word. The country still profits by it, and regards it as a most important security to our constitutional freedom. By his exertions on the Russian armament, he had the satisfaction to save his country from at least one unnecessary, unjust, and expensive war. We must hasten to an occasion where his efforts were less successful.

The beginning of the French revolution gave universal satisfaction to the friends of liberty in this country. Soon after the taking of the Bastille, Mr Fox describes it "as the greatest, and much the best event that ever happened in the world;" and adds, "all my prepossessions against French connections for this country will be at an end, and indeed most part of my European system of politics will be altered, if this revolution has the consequence that I expect." When the king of France was brought back from Varennes, a report having been circulated in England that it was the intention of the national assembly to bring the queen to trial for her life, he composed a letter to Barnave, one of the leading members of the assembly, with whom he was personally unacquainted, exhorting him against such a measure of useless cruelty, which could not fail to bring disgrace on the cause of liberty. The letter was never sent, in consequence of the report proving to be unfounded; but we subjoin some extracts from it, in order to show the spirit in which it was written. After an apology for obtruding his advice on one who was unknown to him, except by reputation, and stating the bad impression that any unnecessary severity to the queen would produce in England; after praising the assembly for the firmness they had displayed on receiving the news of the king's escape, and urging them to show as much clemency and moderation in prosperity, as they had manifested coolness and resolution in danger; after stating the argument for sending the queen out of the country, or, at most, for confining her in a place of security, he proceeds as follows: "De l'autre coté, si on la juge cette malheureuse femme, qu'on la condamne, et qu'elle subisse son sort, je ne sais que trop bien que ce seraient les ennemis de la liberté qui en triompheront. On la peindra cette liberté comme feroce et cruelle, on tachera de la rendre odieuse, et parmi les âmes faibles on ne reussira peut-etre que trop bien. Le despotisme a toujours eu l'addresse de se servir des passions des hommes pour les subjuguer. Il a eu à ses gages la superstition et l'intérêt personnel, et il seroit bien facheux que la pitié, la plus aimable de toutes les faiblesses humaines, se rangeât aussi de son coté. Je ne sais si je me trompe, mais il me parait que vous êtes precisément dans la position où vous pouvez faire une action belle et genereuse sans le moindre danger; c'est-à-dire, que vous êtes dans la prosperité la moins equivoque. Vous avez donné par vos travaux la liberté à votre patrie, et vous trouvez dans elle une recompense aussi touchante que juste. Travaillez actuellement pour le genre humain, et faites aimer la liberté à toutes les nations de la terre, en prouvant qu'elle nourrit dans l'âme non seulement les vertus mâles comme le courage et la justice, mais aussi la douceur, la moderation, et la clemence." Such were the sentiments and conduct of a man, who was afterwards represented to his countrymen as the blind apologist of all the horrors of the revolution, and indifferent spectator of the calamities of the royal family of France.

As the revolution departed from its original character of justice and moderation, its favourers in this country began to fall off. Mr Burke, scandalized at the confiscation of church property, was the first of the Whig party to declare against it. His violent and outrageous quarrel with Mr Fox in the House of Commons is too well known to need to be here related. No event of his life had ever given such unfeigned sorrow to Mr Fox, as this breach with his old friend and political instructor. But he had soon many other losses of the same sort to deplore. The excesses of the revolution, the democratic form it assumed, the fear lest its example should prove contagious in England, filled with alarm the older, richer, and more aristocratic members of the Whig party. Younger and more ardent spirits, looking to the goodness of the cause, disregarded the unfitness of the instrument used to promote it; and, exulting in the progress of political freedom abroad, thought the occasion favourable for extending and enlarging our constitutional rights at home. A schism was gradually formed in the Whig party, which the formation of the Society of the Friends of the People, and the royal proclamation in May 1792, brought to a public explosion. Mr Fox was eagerly courted on both sides; but if he appeared to hesitate, it was only to keep his friends, if possible, together, and prevent a permanent separation, which he foresaw would invest the minister, as it did, with absolute power. But the revolution of the 10th of August, the massacres of September, the success of the French arms under Dumourier, the violence and indiscretion of the friends of reform at home, spread a panic terror over the land; and the minister who had trifled and temporised till it was too late, found himself unwillingly forced into a war, which he had not wisdom to avert or genius to conduct.

We cannot follow Mr Fox in his opposition to this disastrous war, nor in his subsequent efforts for the restoration of peace. On no occasion was the vigour of his intellect, the sagacity of his foresight, the firmness and resolution of his character, more conspicuous than during the struggle he maintained against overwhelming majorities from 1792 to 1797. Till the Duke of Portland, and other alarmists of the Whig party, joined administration in 1794, he always flattered himself with the hope of renewing his connection with his old friends, when their fears should have subsided; and at every harsh or violent act of the government his letters express surprise that the men with whom he had acted so long should support such measures. When finally separated from his old aristocratic connections, and convinced by fatal experience that

the House of Commons had sunk into the passive instrument of ministerial power, his opinions became gradually more inclined to parliamentary reform, from utter despair of seeing the revival of those party connections to which he had been accustomed to look for the preservation of public liberty. But if he appealed to the constituent body against their representatives, he only followed the example which the court and his great opponent had given in the memorable dissolution of 1784. Nothing indisposed him so much against the House of Commons as the indifference it manifested on every occasion where liberty was infringed, or injustice committed by the government. "Arguments against the war and our alliances," he observes, in a letter written in 1794, "are favourably heard in the House of Commons, though they do not get us a vote; but sentiments of liberty, and complaints of oppression, are very little attended to, however well founded. In short, liberty is not popular; and of those who are attached to it there are too many who have wild and impracticable schemes of government, to which the miserable state we are in, both with respect to foreign affairs and our constitution, gives more plausibility and credit than they are by their own merit entitled to. The country seems divided (very unequally I admit) between the majority, who are subdued by fears or corrupted by hopes, and the minority, who are waiting sulkily for opportunities for violent remedies. The few who are neither subdued enough to be silent through fear, nor desperate enough to give up regular opposition, in expectation of more violent measures, are weak both in numbers and weight; but, though weak, we are right, and that must be our comfort." But, however changed the sentiments of the country, his own opinions of the value of political liberty were not altered. "I believe," says he, in another letter to the same correspondent, "the love of political liberty is *not* an error; but if it is one, I am sure I shall never be converted from it, and I hope you never will. If it be an illusion, it is one that has brought forth more of the best qualities and exertions of the human mind than all other causes put together; and it serves to give an interest in the affairs of the world, which without it would be insipid." "We live," he observes on another occasion, "in times of violence and of extremes; and all those who are for creating, or even for retaining, checks upon power, are considered as enemies to order. However, one must do one's duty, and one must endeavour to do it without passion." After relating the final junction of his old friends with administration, he adds, "You will easily imagine how much I feel the separation from persons with whom I had been so long in the habit of agreeing; it seemed in some way as if I had the world to begin anew; and, if I could have done it with honour, what I should best have liked would have been to retire from politics altogether; but this could not be done, and therefore there remains nothing but to get together what remains of our party, and begin, like Sisyphus, to roll up the stone again, which, long before it reaches the summit, may probably roll down again."

The last of these extracts shows that, notwithstanding the defection of some of the friends he most loved and esteemed, he was still convinced of the necessity of party connections, in order to maintain the cause of liberty in this country. He argues the question at length with his correspondent, and concludes by saying, "But the decisive argument upon the subject appears to me to be this: Is there any other mode or plan in this country by which a rational man can hope to stem the power and influence of the crown? I am sure that neither experience nor any well reasoned theory has ever shown any other. Is there any other plan which is likely to make so great a number of persons resist the temptations of titles and emoluments; and, if these things are so, ought we to abandon a system from which so much good has been derived, because some men have acted inconsistently; and because, from the circumstances of the moment, we are not likely to act with much effect?" It was with great reluctance, however, and with great violence to his own wishes, that he persevered in this fruitless struggle. "I am quite sick of politics," he says in August 1794, "and attend to them only because I think it a duty to do so, and that it would be unbecoming my character to quit them at such a moment." His desire to retire from public life became stronger in the following year. "I grow every day to think less of public affairs," he says in April 1795; "I wish I could be persuaded that it was right to quit public business, for I should like it to a degree that I cannot express; but I cannot yet think that it is not a duty to persevere. I am so sure that secession is the measure a shabby fellow would take in our circumstances, that I think it can scarcely be right for us; but, as far as wishes, no man ever wished any thing more. I am perfectly happy in the country. I have quite resources enough to employ my mind, and the great resource of literature I am fonder of every day. However, events and circumstances may happen which may make that right, which I am sure would be pleasant, and I think it not unlikely but they may."

The popular spirit manifested against the treason and sedition bills, in winter 1795, revived his public zeal, but was far from giving satisfaction to his mind. "My view of things," he writes in November 1795, "is, I own, very gloomy, and I am convinced that in a very few years this government will become completely absolute, or that confusion will arise of a nature almost as much to be deprecated as despotism itself. Ministers mean to bring on the first of these evils, and I cannot disguise from myself that there are but too many who wish for the second." After his success at the Westminster meeting against the bills, he says, "It is clear we have the popularity, and I suspect we shall have it universally among the lower classes. I need not tell you how I dislike this state of things, but I cannot submit quietly to Mr Hume's *euthanasia*, which is coming on very fast." As he became more persuaded of the existence of a strong spirit of liberty among the lower classes, he became more inclined to the popular doctrines of parliamentary reform. In 1796 he expresses himself in the following manner upon that subject: "Perhaps, instead of saying *now* that the power of the House of Commons ought to be first restored, and its constitution considered afterwards, it would be better to invert the order, and to say parliament should first be reformed, and then restored to its just influence. You will observe that I state this opinion as being mine *now*, in contradistinction to those times when the Whig party was only beaten, but not dispersed, and when I certainly *was* of a different opinion. At present I think we ought to go further towards agreeing with the democratic or popular party than at any former period, for the following reasons: *We*, as a party, I fear can do nothing, and the contest must be between the court and the democrats. These last, without our assistance, will either be too weak to resist the court, and then comes Mr Hume's *euthanasia*, which you and I think the worst of all events; or, if they are strong enough, being wholly unmixed with any aristocratic leven, and full of resentment against us for not joining them, will go probably to greater excesses, and bring on the only state of things which can make a man doubt whether the despotism of monarchy is not the worst of all evils."

The time at length arrived when the state of things to

which he alluded in his letter of April 1795 came to pass. His remaining political friends were persuaded that it was useless to persevere longer in their parliamentary exertions, and that it was even "in some degree hurtful, as tending to deceive the country into an opinion that the House of Commons was still a place in which it was worth while to try the effect of argument and reason." When he found that no good was to be done in parliament, that no beneficial impression was to be made on the country, and that the friends for whom he was ready to sacrifice his time and inclinations wished him to retire from public life, with doubt and hesitation in his mind as to the propriety of the measure, he gave his consent to the secession; resolving no longer to attend his duty in the House of Commons, unless particularly called upon to do so by his own constituents.

Having once retired to St Anne's, he found such enjoyment in the calmness and tranquillity of a country life, that it was with the utmost difficulty he could now and then be brought back to the House of Commons. The happiest years of his life were those which he passed in retirement from 1797 to 1802. He still took a lively interest in public concerns, and applauded and encouraged the exertions of his friends when they returned to parliament, but he could seldom be induced to follow their example. His time passed placidly and agreeably in books, conversation, and the society of his family. He had always been fond of gardening, and his residence in the country gave him a turn for farming. Of the amusements of his early years the love of shooting was the only one in which he continued to indulge, and the exercise it gave him preserved his health. His passion for literature, which had never subsided entirely, revived and became stronger than ever. Poetry and criticism were his favourite pursuits, and history his amusement. He applied with ardour to the study of the Greek tragedians, and as his proficiency increased, he found an agreeable occupation for his mind in the niceties and difficulties of that noble language. Some time after his retreat he conceived the plan of writing a History of the Revolution of 1688. He had many years before expressed himself in the following manner, of the work of our great historian: "I think Mr Hume's History of Charles I. the most mischievous book that ever was written. It is written with infinitely more art than any other part of his work, and is, I think, in that view a masterpiece. I do not think any answer to it or comment on it would do much good, or at least not so much as another history of the times written with his art, or even with the half of it, in the opposite view." But, though his opinion of the utility of a new history of the civil war, as an antidote to Hume, may possibly have first turned his thoughts to a work on English history, the period he selected for his own labours shows that he had no intention to set himself up as a rival to that great historian. His sole object seems to have been, to tell the story of the Revolution, to explain how it was brought about, and to show in what its constitutional value consisted. Had he lived to complete his plan, the criticisms on Hume, in his introduction, would have formed but a small part of his book.

Mr Fox went abroad with Mrs Fox in summer 1802, partly from curiosity to see France after the extraordinary changes that had taken place in that country, and partly to collect documents for his history. As the constant friend of peace, he was received with enthusiasm wherever he went by the French people, and treated with distinguished civility and attention by their government. He had several long conversations with the first consul, in which the latter talked to him with the utmost freedom on a variety of topics; on the concordat then recently made, on the trial by jury, on the licentiousness of the English newspapers, on the difference between Asiatic and European society. On one occasion Napoleon having insinuated that Mr Windham was concerned in the assassination plots against his person, Mr Fox vindicated his old friend with warmth against so odious and unfounded an imputation. Having finished his labours at Paris, during which he collected a large mass of materials for his history, he went to La Grange, the country seat of his friend La Fayette, and after passing some days there most agreeably, returned to England.

On his arrival in London he found great irritation in England against the consular government, and an absurd cry for war raised by the newspapers, and re-echoed by all who expected in any way to profit by that calamity. Ministers were apparently undecided, and, in the hopes of confirming them in a pacific disposition, he resolved for a short time to renew his attendance in parliament. "I shall attend on the address," he says, "because, though, if the ministry is warlike, I have no hope of dissuading them; on the other hand, if they are pacific, I may serve in some degree to encourage them." Besides his general objections to war, where it could be avoided with honour, he thought there was "in this case a moral certainty of failing in our object, and of aggrandizing France still more than we had done." Peace should be preserved, "if it could be done with honour;" and he had no doubt it might, provided our government was so disposed. If Pitt, who had not yet declared himself, should be for peace and Addington, there would be no occasion for the old opposition taking an active part; but if he should join the war party, or "hold a conduct between peace and war," then Addington will want support, "and the support given him will be both useful and honourable." He had been told that he should "be as much abused for pacific language now as he had been ten years before, but being in parliament, he was determined not to blink such a question;" and, on making the trial, found "his speech in favour of peace better received by the house than any he had made since the Russian armament." The country in general, he was persuaded, was inclined to peace; and while there was "hope of contributing to prevent war, he felt himself in a manner bound" not to discontinue his attendance in the House of Commons. When the short session before Christmas closed, he still thought ministers sincerely desirous of maintaining peace. "If I have any fears," he says on the 29th of December 1802, "it is only from a suspicion of a want of courage in ministers to speak out what they really think, and if they should *long* continue to be afraid of speaking bold pacific language, ill humours may arise, and war begin without any wish for it in either government."

It has been invidiously said, that Mr Fox, after his return from Paris, was unwillingly dragged from his retirement by the importunity of his friends, in order to support their views in parliament, and that his health and comfort were sacrificed to their party objects. The fact is directly the reverse. It was he who urged them to attend, not they who solicited him. His return to public life was his own spontaneous act, unsolicited and unexpected by his friends. His object, in the first instance, was to assist in the preservation of peace; and when the message in March 1803 had opened his eyes to the real intentions of the ministry, his indignation at the hollowness and duplicity of their conduct made him persevere in his parliamentary attendance. From the state of parties in the House of Commons he began also to entertain hopes of the revival of a Whig opposition, such as had existed before the fatal schism in 1792; and with his opinions of the necessity of party connections, as the only

means of maintaining public liberty in this country, there was no personal sacrifice he was not willing to make for the attainment of such an end. The revival of his former connection with his old friends was the object nearest to his heart; and in Lord Grenville, though a new associate, he found, as he had formerly done in Lord North, an honourable coadjutor, with whom he could act in perfect confidence, though they had differed warmly on points that were no longer the subjects of public discussion. He was even ready to form a junction with Mr Pitt, till he discovered that Pitt, though willing to join in opposing particular measures of administration, would not break with the court by going into regular opposition. It is a certain fact, that, of all his party, Mr Fox was the person most anxious to form a coalition with Lord Grenville; and that, whatever difficulties occurred to retard that junction, they arose not from him, but from his friends. He considered then, as he had done from the time of the American war, the influence of the crown to be the most dangerous enemy to good government in this country; and the violence expressed for war, after the royal message, contrasted with what he conceived to have been previously the general disposition for peace, he regarded as a strong confirmation of all his apprehensions. "The king's minister," he says in March 1803, "be he who he may, is in peace, at last, all powerful; whether or not, in case of a war, the universal apprehension of mischief from the weakness of those men could do any thing, may be more of a question, but even in that case I think the crown in earnest would beat us all." This influence, he contended, not only governed men's actions, but even swayed their opinions. "I should not be surprised," he says in January 1804, "if in a short time the present minister is reckoned the ablest man in the kingdom; or, if that cannot be compassed, it will be thought and maintained, that a minister without abilities is the best for this country." He was anxious for a junction of parties, not from motives of personal ambition, but in order to counteract this servility. "A stand should be attempted, which, though unsuccessful at present, will keep something alive against other times. To temporise is certain, absolutely certain, confirmation of the evil; no nation ever did, or ever can, recover from slavery by such methods."

The first distinct overture for a formal coalition of what were then called the new and old opposition, was made in January 1804, and came from the friends of Lord Grenville. It was proposed to co-operate in a systematic opposition, for the purpose of overturning Mr Addington's administration, and of substituting in its place one upon the most comprehensive basis possible. To this proposal Mr Fox was willing to have acceded at once; but, owing to some repugnance on the part of his friends, it was settled that the two parties should co-operate and concert together the measures to be brought forward in parliament, in order to give to their debates and divisions all the strength they could, without any formal or compact engagement in case of success. The same proposition had been made to Mr Pitt, who owned that the present ministry was weak and inadequate to the crisis, that their dismission would be a benefit to the country, and that, in case of such an event, an administration should be formed on the broadest possible basis. If his majesty, on such an occasion, were to send for him, he should think it right to endeavour to comprehend in the arrangement all parties, and even those who had been most hostile to him; but though, on many points, he would support the new opposition if it took place, he was determined never to engage with any set of men in systematic opposition. Such was the state of parties at the meeting of parliament in February 1804. As the session advanced Mr Pitt grew more hostile to ministers; and, after the Easter recess, the three parties in opposition acted in concert with so much vigour, that Mr Addington thought it prudent to resign. Mr Pitt, who was sent for to form a new administration, had previously declared that he would endeavour to form one in conjunction with Lord Grenville and Mr Fox; but if he found his majesty impracticable, he should feel himself bound to try one by himself. The result is well known. His majesty was found to be impracticable on the subject of Mr Fox. Lord Grenville, though unfettered by engagements, refused to concur in an administration from which Mr Fox was excluded; and, by his conduct on this occasion, "satisfied those" persons of the old opposition, "who had been most prejudiced" against a junction of the two parties. Mr Pitt, abandoned by all, except his personal friends and adherents, was compelled to coalesce with the wrecks of the administration he had contributed to destroy.

After various ineffectual attempts, during the recess, to strengthen the government, Mr Pitt found himself obliged, before the meeting of parliament, to take back Mr Addington into office. A fresh quarrel ensued; and, at the close of the session, Mr Addington (now Lord Sidmouth) and his friends again resigned. Insinuations were then thrown out of an intention to negotiate with opposition; but, if such overtures had been made, the new engagements contracted on the Continent, independent of other reasons, must have put a stop to the negotiation. Russia, offended at the arrogance of Napoleon, had expressed her desire to form a closer connection with Great Britain. It had been the advice of Mr Fox that advantage should be taken of this disposition to propose reasonable terms of peace to France, under the mediation of Alexander, and, if these were refused, to conclude a defensive alliance with Russia, but on no account to provoke a fresh Continental war, which must ruin Austria if unsuccessful. Unhappily this advice was not taken. Austria was seduced, or rather bribed, into a declaration of hostilities. The war was pre-eminently unfortunate, and all hope for a time extinguished of any balance to the power of France upon the Continent.

The death of Mr Pitt dissolved the administration he had formed. Lord Grenville was sent for by the king, and had no difficulty in persuading his majesty to accept of the advice and services of Mr Fox. When the different parts of the new administration were to be cast, his hope and desire of peace induced Mr Fox to take the office of secretary of state for foreign affairs; and, before his fatal illness, he had begun a negotiation for peace, with every apparent prospect of success. The short time he was in office prevented him from realizing the sanguine expectations which his friends and the public had conceived from his past conduct and principles of government. It ought to be remembered, however, that it was to his firmness Mr Windham was indebted for the success of his limited service bill; a measure that had to encounter every opposition which power and prejudice could raise against it; and that to his exertions, and to those of Lord Grenville, was owing a resolution of both houses of parliament to abolish the slave trade, which Mr Pitt, in the plenitude of his power, had failed to obtain.

Mr Fox had inherited an uncommonly vigorous constitution; but, about two years before his death, he had an illness at Cheltenham, which probably laid the foundation of the malady that occasioned his death. His attendance on Lord Nelson's funeral, in January 1806, brought on a complaint to which he was ever after occasionally liable. The duties of office, and the fatigue of constant attendance on the House of Commons, did not tend to re-

store or confirm his health. About the middle of June he had symptoms of dropsy, both general and local, and soon afterwards his complaint had made such alarming progress as to excite the greatest fears for his life. The universal interest excited in his fate afforded the surest evidence of his great popularity. From the remotest corners of the kingdom letters arrived daily to his family, expressing the deepest concern in his situation, and recommending remedies of all sorts for his disease. His malady, in the mean time, gained ground daily, and his physicians were at length compelled to have recourse to the common surgical operation for dropsy of the belly. The relief obtained, as usual, was but temporary. The operation was repeated, and soon after he fell into a state of languor, from which he never recovered. He expired on the 13th of September 1806, having retained his senses and understanding to the last. It has been said that his death was accelerated by the exhibition of digitalis, administered in the vain hope of effecting a perfect cure of his disease; but the story is utterly false and unfounded, and has been publicly contradicted by his physicians. The cause of his complaint was ascertained to be a schirrous affection of the liver.

"Mr Fox," to use the words of one who knew him well during the last fifteen years of his life, and who has delineated his character with equal truth, force, and discrimination,[1] "united, in a most remarkable degree, the seemingly repugnant characters of the mildest of men and the most vehement of orators. In private life he was gentle, modest, placable, kind, of simple manners, and so averse from dogmatism, as to be not only unostentatious, but even something inactive in conversation. His superiority was never felt but in the instruction which he imparted, or in the attention which his generous preference usually directed to the more obscure members of the company. The simplicity of his manners was far from excluding that perfect urbanity and amenity which flowed still more from the mildness of his nature than from familiar intercourse with the most polished society of Europe. The pleasantry perhaps of no man of wit had so unlaboured an appearance. It seemed rather to escape from his mind than to be produced by it. He had lived on the most intimate terms with all his contemporaries distinguished by wit, politeness, or philosophy, or learning, or the talents of public life. In the course of thirty years he had known almost every man in Europe whose intercourse could strengthen, or enrich, or polish the mind. His own literature was various and elegant. In classical erudition, which by the custom of England is more peculiarly called learning, he was inferior to few professed scholars. Like all men of genius, he delighted to take refuge in poetry, from the vulgarity and irritation of business. His own verses were easy and pleasant, and might have claimed no low place among those which the French call *vers de société*. The poetical character of his mind was displayed by his extraordinary partiality for the poetry of the two most poetical nations, or at least languages, of the west, those of the Greeks and of the Italians. He disliked political conversation, and never willingly took any part in it."[2]

"To speak of him justly as an orator would require a long essay. Everywhere natural, he carried into public something of that simple and negligent exterior which belonged to him in private. When he began to speak, a common observer might have thought him awkward; and even a consummate judge could only have been struck with the exquisite justness of his ideas, and the transparent simplicity of his manners. But no sooner had he spoken for some time than he was changed into another being. He forgot himself and every thing around him. He thought only of his subject. His genius warmed and kindled as he went on. He darted fire into his audience. Torrents of impetuous and irresistible eloquence swept along their feelings and conviction. He certainly possessed above all moderns that union of reason, simplicity, and vehemence, which formed the prince of orators. He was the most Demosthenean speaker since the days of Demosthenes. 'I knew him,' says Mr Burke, in a pamphlet written after their unhappy difference, 'when he was nineteen; since which time he has risen, by slow degrees, to be the most brilliant and accomplished debater the world ever saw.'

"The quiet dignity of a mind roused only by great objects, the absence of petty bustle, the contempt of show, the abhorrence of intrigue, the plainness and downrightness, and the thorough good nature, which distinguished Mr Fox, seem to render him no unfit representative of the old English character, which, if it ever changed, we should be sanguine indeed to expect to see it succeeded by a better. The simplicity of his character inspired confidence, the ardour of his eloquence roused enthusiasm, and the gentleness of his manners invited friendship. 'I admired,' says Mr Gibbon, after describing a day passed with him at Lausanne, 'the powers of a superior man, as they are blended, in his attractive character, with all the softness and simplicity of a child; no human being was ever more free from any taint of malignity, vanity, or falsehood.'

"The measures which he supported or opposed may divide the opinion of posterity, as they have divided those of the present age. But he will most certainly command the unanimous reverence of future generations, by his pure sentiments towards the commonwealth; by his zeal for the civil and religious rights of all men; by his liberal principles, favourable to mild government, to the unfettered exercise of the human faculties, and the progressive civilization of mankind; by his ardent love for a country of which the well-being and greatness were, indeed, inseparable from his own glory; and by his profound reverence for that free constitution which he was universally admitted to understand better than any other man of his age, both in an exactly legal and in a comprehensively philosophical sense." (J. A—N.)

Fox, *George*, the founder of the sect of Quakers, was born at Drayton, Leicestershire, in the year 1624. His father, a zealous Presbyterian, was a weaver. Young Fox, from his earliest years, showed uncommon gravity, and participated in none of the diversions natural to his age; he courted solitude, and when he spoke it was in a melancholy tone. His parents were unable to give him any education beyond reading and writing, but they early inspired him with sentiments of religion and virtue. Fox was at first placed with a wool-merchant, and sent to tend sheep in the woods; a circumstance which seems to have confirmed his

[1] *Character of Mr Fox*, by Sir James Mackintosh. Published in Dr Parr's Collection, entitled *Characters of Mr Fox*, by PHILOPATRIS VARVICENCIS.

[2] This is true of Mr Fox in the latter part of his life only. Till his separation from his old friends in 1793 his mind was too full of political subjects not to take an eager part in political conversation even in private; and, when a young man, instead of being somewhat inactive in conversation, he was very much the reverse. Dr Johnson was mistaken in supposing him habitually silent when in company, and has assigned a reason for his supposed taciturnity quite inconsistent with his real character.

inclination for a solitary and contemplative life. He was then put as an apprentice to a shoemaker at Nottingham; and from the accounts of the times we learn, that as he wrought at his trade, he used to meditate much on the Scriptures, which, with his solitary course of life, improving his natural melancholy, induced him at length to fancy himself inspired; and in consequence he set up as a preacher. He proposed but few articles of faith, insisting chiefly on moral virtue, mutual charity, the love of God, and a deep attention to the inward motions and secret operations of the Spirit; he required a plain, simple worship, and a religion without ceremonies, making it a principal point to wait in profound silence for the directions of the Holy Spirit. Fox met with much rough treatment on account of his zeal, was often imprisoned, and several times in danger of being put to death. But, in spite of all discouragements, his sect, which received the name of *Quakers*, prevailed, and many considerable men were led to join them; amongst whom were Barclay and Penn. Fox died on the 16th of January 1690. He was comparatively an uneducated man, as we have already seen; but he possessed in an eminent degree the talent of persuasion, since, although born in an inferior grade of society, and devoid of any but the simplest instruction, he succeeded in recommending his doctrine to men of a superior rank in society. It was undoubtedly owing to this circumstance that the society of Quakers, or, as they call themselves, Friends, was enabled to outlast so many other sects founded by enthusiasts, which have generally disappeared immediately after the death of their authors; whereas Quakerism acquired every day new force, and the laws which at first persecuted, ended by tolerating and even protecting it. Fox, however, only laid the foundation; it was reserved for Barclay and Penn to raise the superstructure. The writings of Fox have been collected in three volumes folio; the first containing his Journal, which is eminently curious; the second, his Correspondence; and the third, all that he has written on his Doctrine. Some persons have indeed pretended that he is not really the author of these different productions; but his followers, on the other hand, maintain that whatever is most admirable in this collection really proceeded from the pen of their patriarch.

Fox, *John*, the martyrologist, was born at Boston in Lincolnshire, in the year 1517. At the age of sixteen he was entered a student of Brazen-Nose College in Oxford; and in 1543 he took his degree of master of arts, and was chosen fellow of Magdalen College. He discovered an early genius for poetry, and, conformably to the taste of his age, wrote several Latin comedies upon subjects taken from Scripture. Of these, one still remains, entitled *De Christo Triumphante*, printed at London in 1551, and at Bâle in 1556, 8vo, and reprinted in 1672. But having forsaken the muses, he applied himself with great assiduity to the study of theology and church history; and having manifested an inclination, which he took no pains to conceal, for the doctrines of the Reformation, he was, in the year 1545, expelled from his college as a heretic, happy, it is said, to have fared no worse. He had lost his father early in life, and, as his mother had married again, his stepfather availed himself of this occurrence to retain the whole of his patrimony, knowing that Fox would not venture to sue him for restitution. This rascality on the part of his mother's husband reduced him to the greatest distress; but he soon afterwards found an asylum in the house of Sir Thomas Lucy, Warwickshire, who employed him as tutor to his children. When this engagement expired, Fox, who had in the meanwhile married the daughter of a citizen of Coventry, proceeded to London; but finding no immediate means of subsistence, he was again reduced to absolute want. Relief, however, at length came, and in a manner which is described as almost miraculous. As he was one day sitting in St Paul's church, emaciated with hunger, a stranger accosted him familiarly, and, bidding him be of good cheer, put a sum of money into his hand; telling him, at the same time, that new hopes were at hand. And, in fact, he was three days thereafter received into the family of the Duchess of Richmond, as tutor to the Earl of Surrey's children, who, upon their father being sent to the Tower, were committed to her care. In this family he lived at Ryegate in Surrey, during the latter part of the reign of Henry VIII., the entire reign of Edward VI., and part of that of Queen Mary; but he could never discover the generous person who had at once relieved his distress and predicted his good fortune. At length, however, being persecuted by his implacable enemy Bishop Gardiner, he was obliged to seek refuge abroad; and he selected as the place of his retreat Basil in Switzerland, where he subsisted by correcting for the press. But on the death of Queen Mary he returned to England, where he was graciously received by his former pupil the Duke of Norfolk, who retained him in his family as long as he lived, and bequeathed him a pension at his death, which took place in 1563. Mr Secretary Cecil also bestowed on him a rectory near Salisbury; and, in point of fact, he might have obtained considerable church preferment, had it not been for his unwillingness to subscribe to the canons. He died in the year 1587, in the seventieth year of his age, and was buried in the chancel of St Giles's, Cripplegate. Fox was a man of great industry, and considerable learning; a zealous, but not a violent reformer; a nonconformist, but not an enemy to the Church of England. The most celebrated of his works is that which is entitled *Acts and Monuments of the Church*, and commonly called *Martyrology*, containing a history of the troubles in the Church of Rome, since the tenth century, particularly in England and Scotland. It was published at London, 1563, in folio, but afterwards augmented and printed for the fourth time in 1583, two vols. folio, and in 1632, three vols. folio. He relates in detail the history of the martyrs of the Protestant religion, but embellishes his narrative with so many marvellous circumstances, that his enemies, it must be confessed, had some reason in applying to it the name of Legend. The Catholics, in particular, reproached him with passion and with grossness; and, what was far more serious, accused him of having often altered the truth in order to swell the number of martyrs to his creed. Nor can it be denied that in the first edition, he had enrolled amongst the number of those who had sealed their testimony with their blood persons still living, and who remonstrated against the honour intended for them. But notwithstanding all these and many other objections, some of which are undoubtedly well founded, the *Martyrology* met with prodigious success in England, where, amidst all the changes which have taken place in taste and opinion, it still maintains its ground. The other writings of Fox, which were very numerous, consist of works on theology, and particularly controversy; and some of his letters which have been preserved reflect honour on his character as a man of sense and humanity.

FOX-GLOVE (*Digitalis purpurea*), an herbaceous plant, inhabiting the temperate and southern parts of Europe. See BOTANY, vol. v., p. 202. Nat. Ord. *Scrophulariaceæ*. The flowers of this beautiful plant are usually purple; but sometimes white. When fresh, it possesses a bitter, nauseous taste, and is violently emetic and cathartic. When prepared and administered medicinally, it has the remarkable property of diminishing the strength and frequency of the pulse, and is at the same time diuretic; hence it is much esteemed as a remedy in diseases of the heart and dropsy.

FOX-HOUND. See HOUND.

FOYERS. See INVERNESSHIRE.

FOYLE, a river and lough in Ireland. See DONEGAL.

FRACASTORIO, HIERONYMOUS, one of the most learned men of his time, was born at Verona in the year 1483. Two singular circumstances are related of him in

his infancy; one that his lips adhered so closely when he came into the world, that a surgeon was obliged to divide them with his incision knife; and the other, that his mother was killed with lightning, whilst he, though in her arms at the moment, escaped unhurt. Fracastorio was a man of such admirable parts, and made so great progress in everything he undertook, that in time he became eminently skilled not only in the belles-lettres, but in most arts and sciences. He was a poet, a philosopher, a physician, an astronomer, and a mathematician; and he was also a man of consequence in his time, as appears from the fact of Paul III. having made use of his authority to remove the council of Trent to Bologna, under the pretext of a contagious distemper, which, as Fracastorio declared, made it no longer safe to continue at Trent. He was intimately acquainted with Cardinal Bembo, Julius Scaliger, and most of the great men of his time. Fracastorio died of apolexy at Casi, near Verona, on the 8th of August 1553; and in 1559 the town of Verona erected a statue in honour of him. Fracastorio was the author of many works, both as a poet and a physician; but no man was more disinterested in both capacities, for as a physician he practised without fees, and as a poet he was indifferent to fame. It is owing to this that we have so little of his poetry; and that his odes and epigrams, which were read in manuscript with admiration, have now been lost. His medical productions are as follow:—

Syphilidis, sive Morbi Gallici libri tres, Verona, 1530, in 4to, afterwards frequently reprinted. *De Vini Temperatura*, Venice, 1534, in 4to. *Homocentricorum, sive de Stellis liber unus*, and *De Causis Criticorum Dierum libellus*, Venice, 1535, in 4to. *De Sympathia et Antipathia Rerum liber unus; De Contagionibus et Contagiosis Morbis, et eorum curatione, libri tres*, Venice, 1546, in 4to. All the poetical productions of Fracastorio were collected and printed at Padua, 1728, 8vo. His complete works appeared for the first time under the title of *Hieronymi Fracastorii Veronensis Opera Omnia, in unum proxime post illius mortem collecta; accesserunt Andreæ Naugerii patricii Veneti Orationes duæ, Carminaque nonnulla*. Venetiis apud Juntas, 1555, in 4to. Besides the works already mentioned, there are included in this collection the three following, which appeared for the first time, viz.:—*Naugerius, sive de Poetica dialogus; Turrius, sive de Intellectione dialogus, libri ii. Alcon, sive de cura Canum Venaticorum. Fracastorius, sive de Anima dialogus.*

FRACTION, in *Arithmetic* and *Algebra*, a broken part or division of an unit or integer; or a number which stands to a unit in the relation of a part to its whole. Fractions are usually divided into decimal, sexagesimal, and vulgar. See ALGEBRA, and ARITHMETIC.

FRACTURE. See SURGERY, and MINERALOGY.

FRAISE. See FORTIFICATION.

FRAME, among *printers*, a stand to support the cases in which the types are distributed. Among *founders*, a kind of ledge inclosing a board filled with wetted sand, and which serves as a mould for castings. It also denotes a sort of loom, on which linens, silks, or stuffs are stretched for embroidering or quilting.

FRAMLINGHAM, a market-town of England, county of Suffolk, on an eminence near one of the sources of the Alde, 14 miles N.E. of Ipswich. The church is a fine old edifice, constructed of black flintstone, with a carved roof and several monuments of the Norfolk family, and surmounted by a tower 96 feet high. The castle of Framlingham was an important fortress in the middle ages, and hither Queen Mary retreated on the death of Edward VI. The remains consist of the walls, 44 feet high and 8 feet thick, 13 towers 58 feet high, a gateway, and some outworks. Market-day Saturday. Pop. of parish (1851) 2450.

FRANC, a French silver coin of the value of nearly tenpence sterling. The ancient franc, or frank, was a gold piece in value somewhat more than the gold crown; and the old silver franc was in value a third of the gold one.

FRANCAVILLA, a town of Naples, province of Otranto, 14 miles W.S.W. of Brindisi. The town is large and regularly built, the streets are wide and straight, and the houses showy, though in a heavy style of architecture. A considerable part of the town was thrown down by an earthquake in 1734, and the houses erected since are only one story high. The main street is handsome, and avenues to the gates are well planted, and afford an agreeable shade. It has a cathedral, college, several hospitals and convents; and manufactures of woollen and cotton stuffs, earthenware, and snuff. Pop. 12,000. There are several other towns of this name in Naples.

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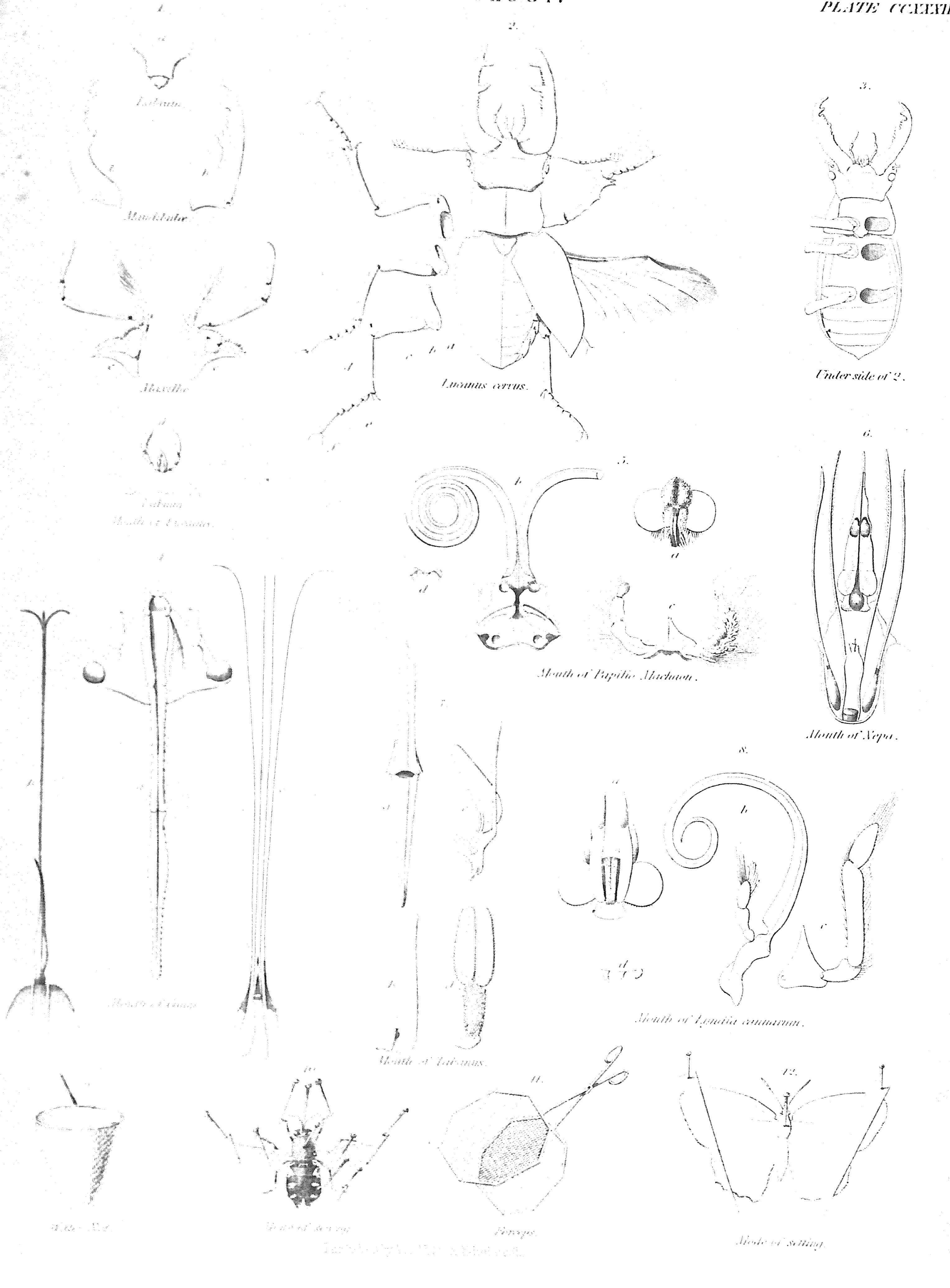
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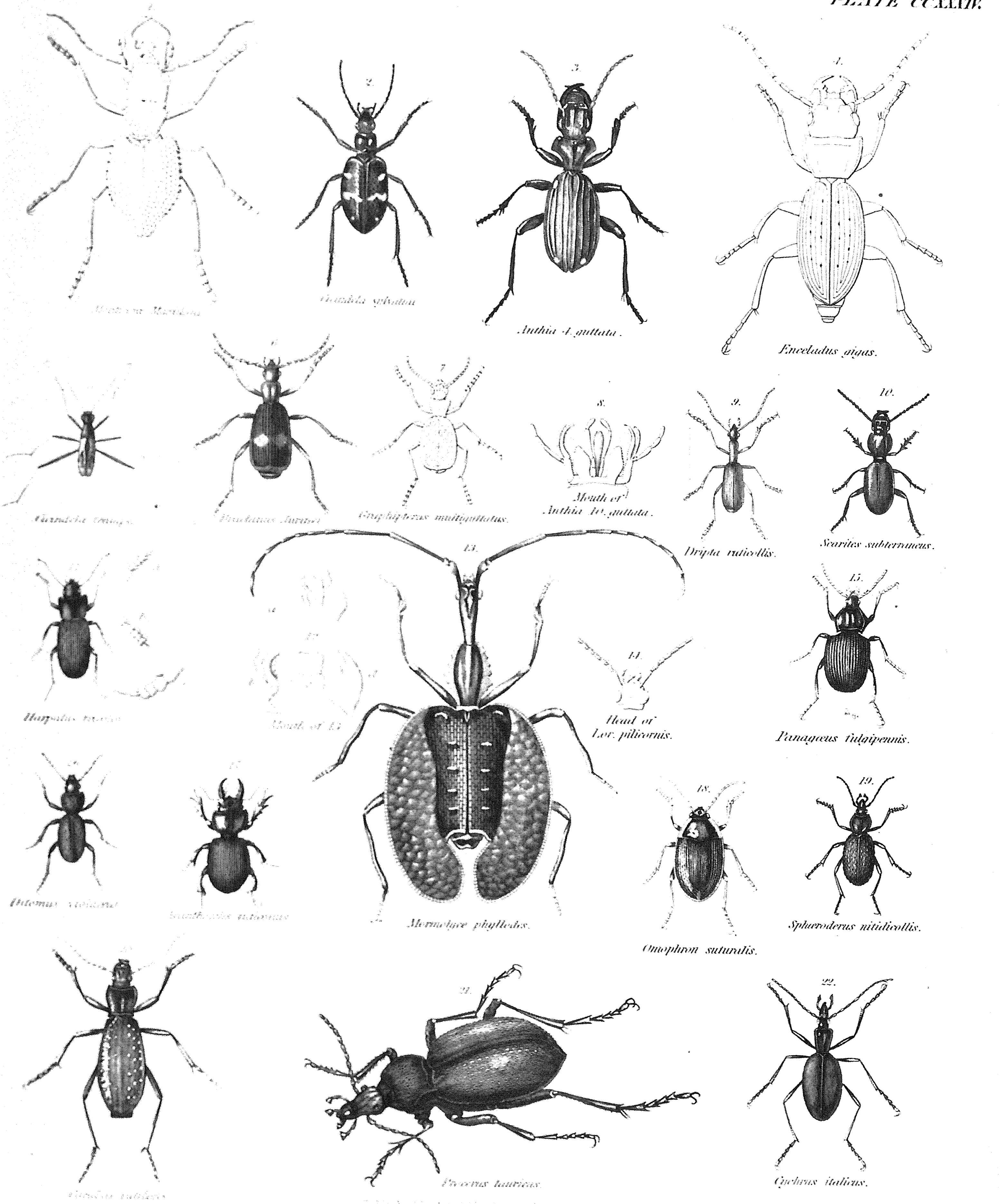
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Scarites subterraneus.
Head of Lor. pilicornis.
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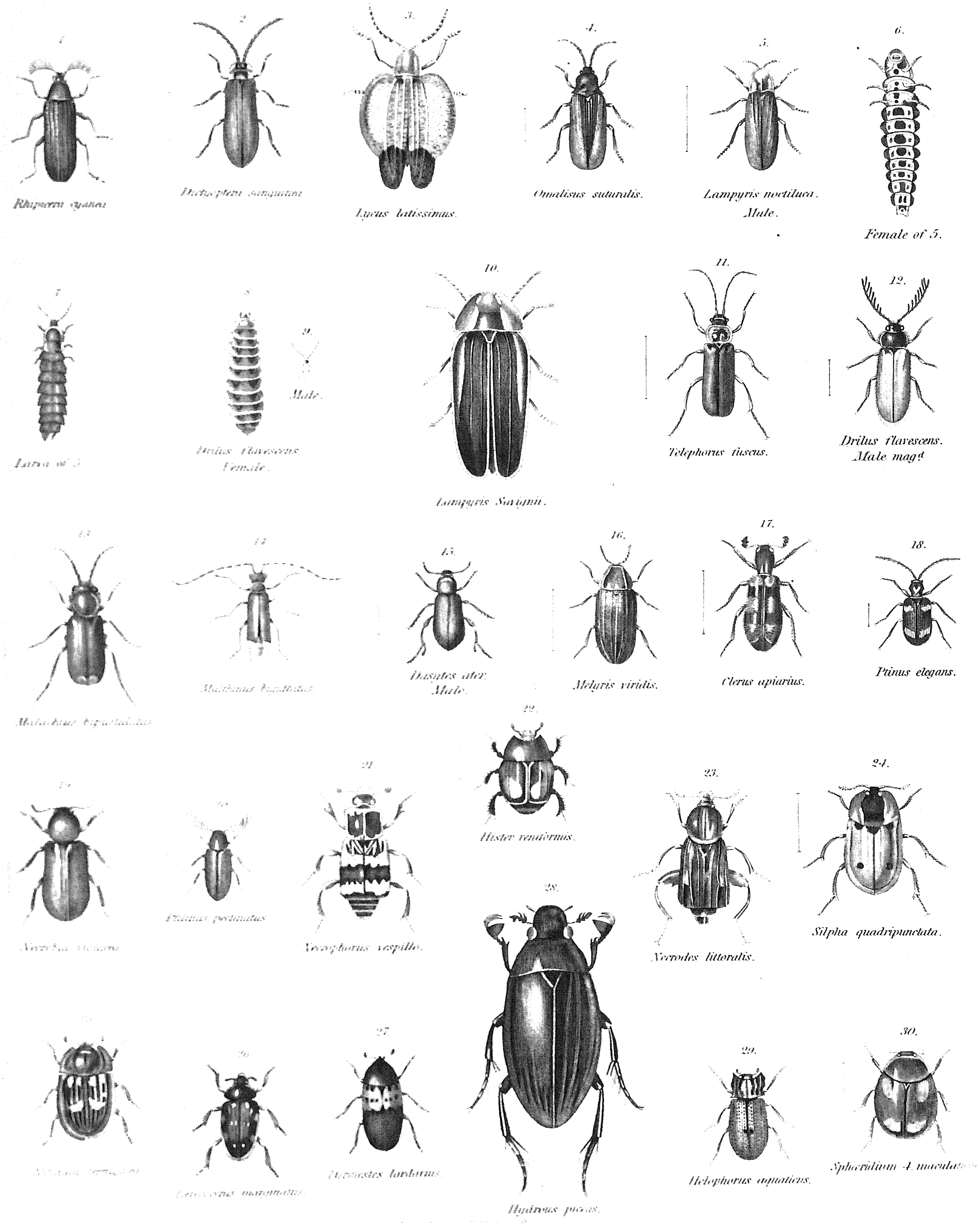
Sphæroderus nitidicollis.
Procerus tauricus.
Cychrus italicus.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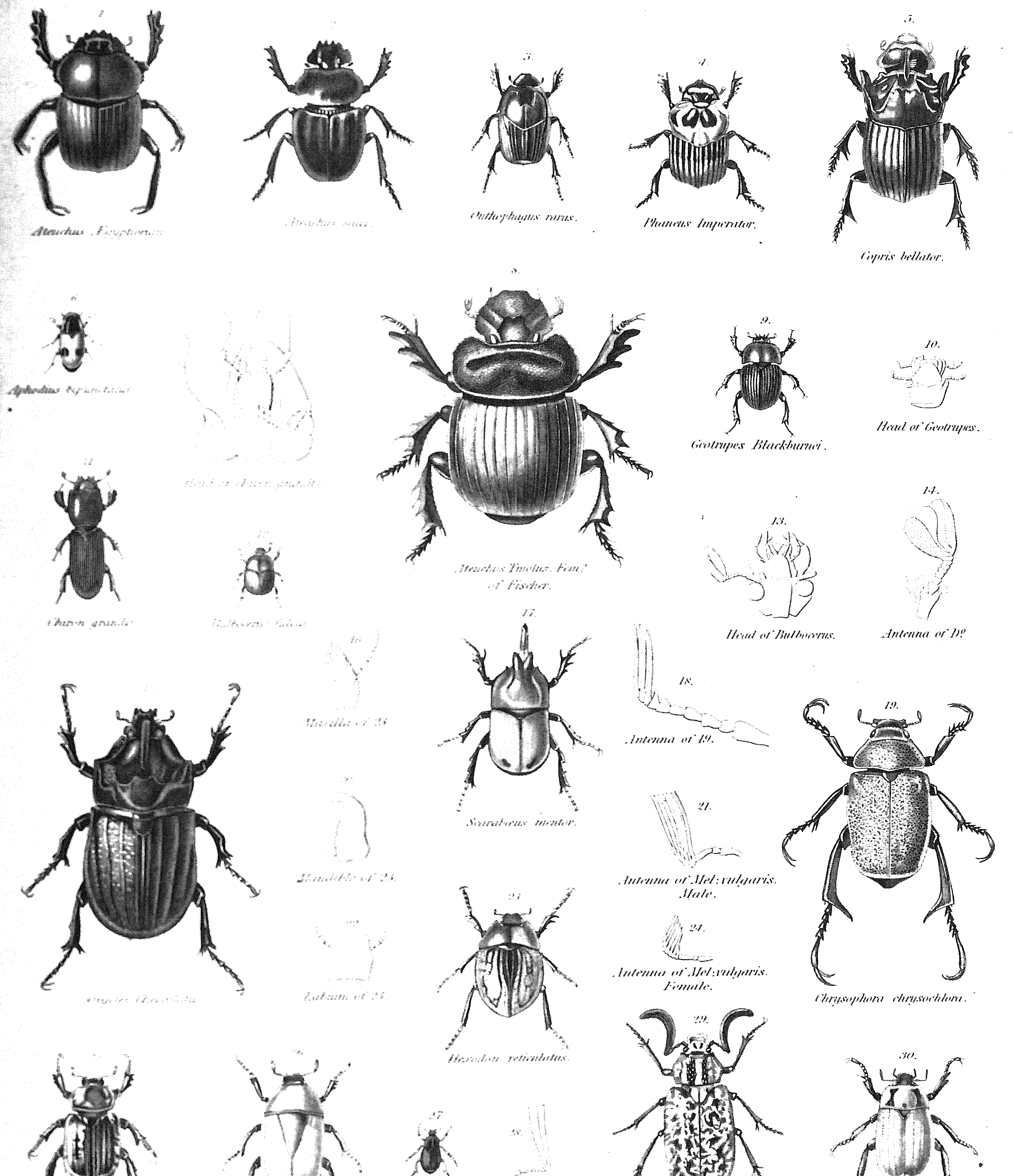
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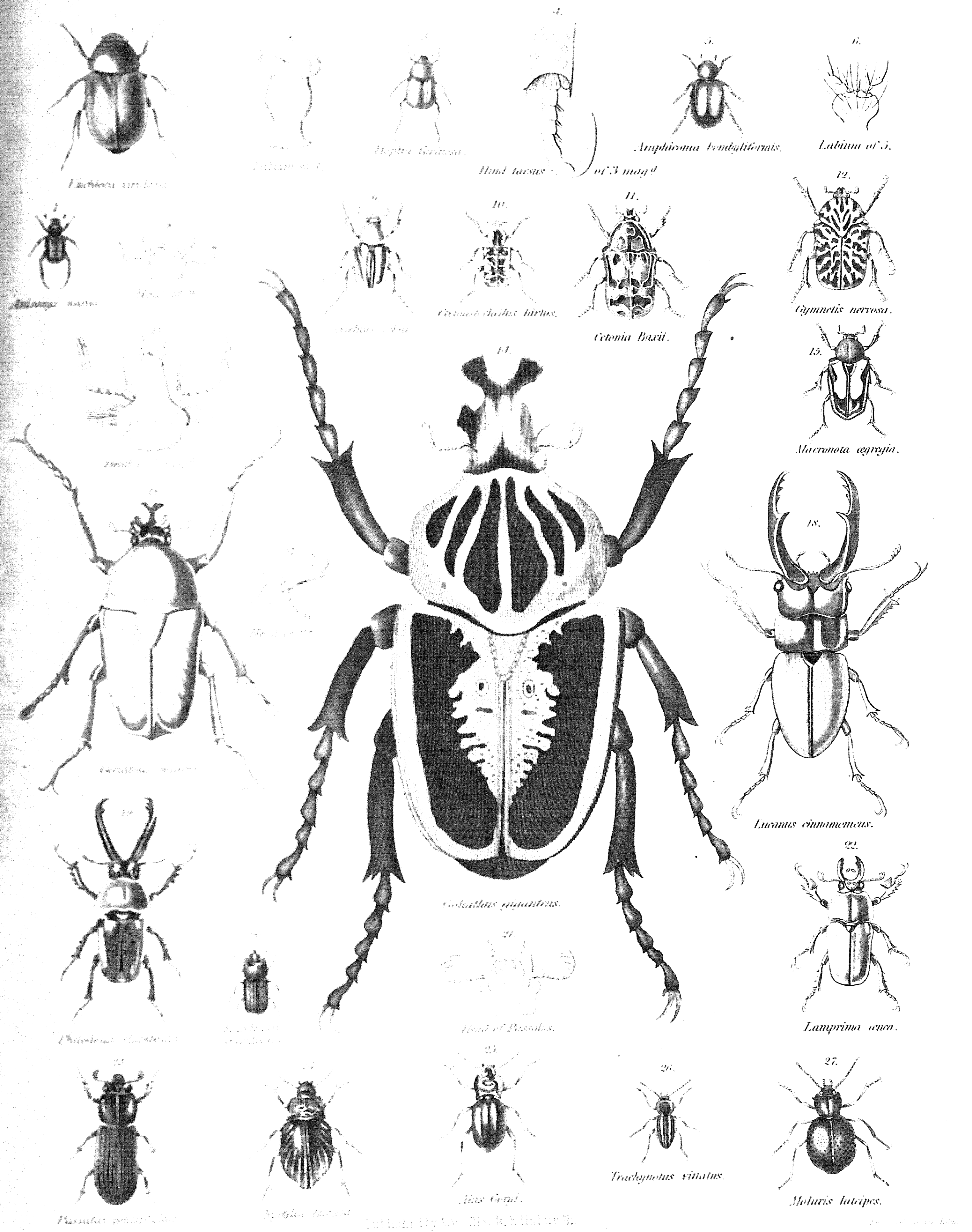
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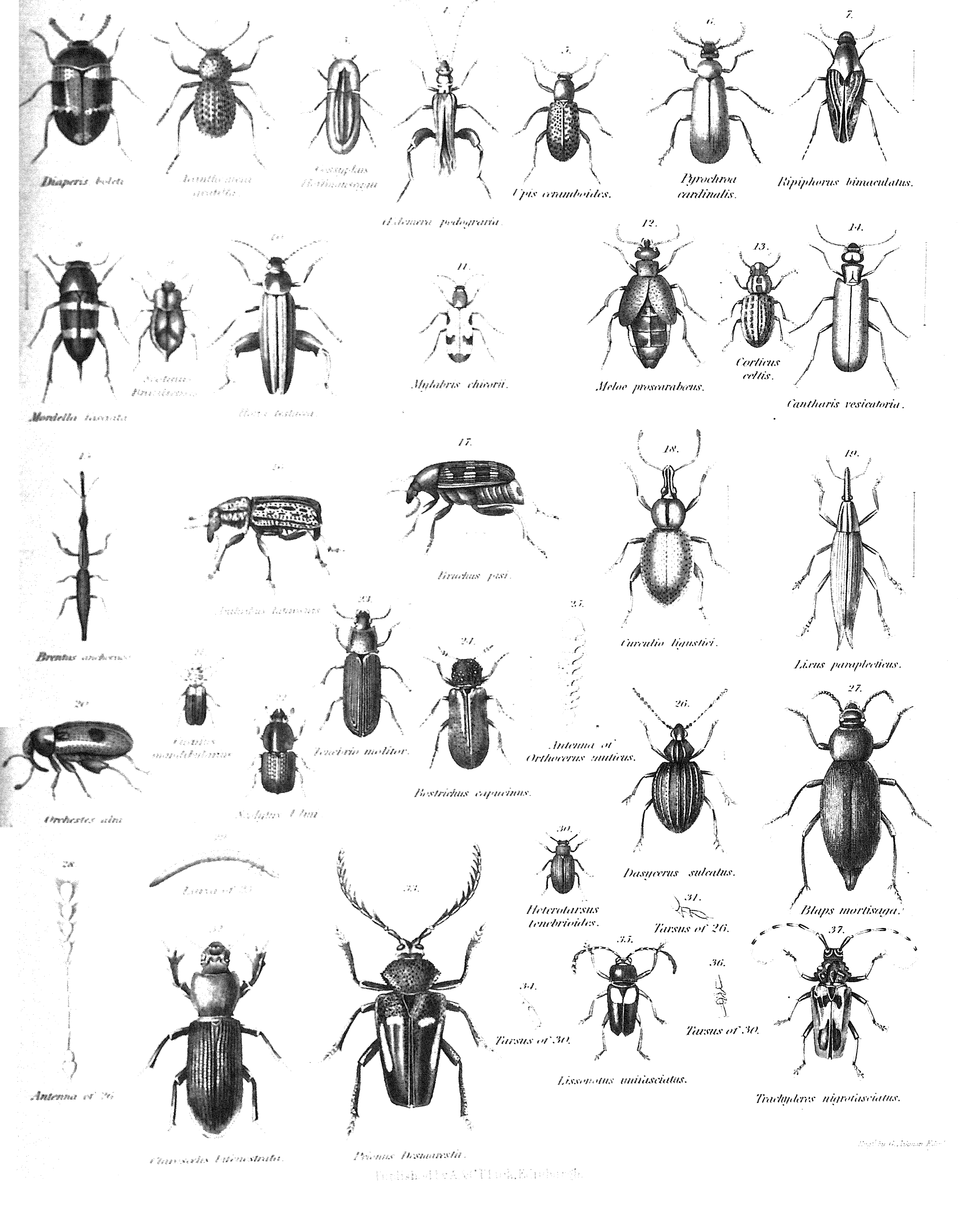
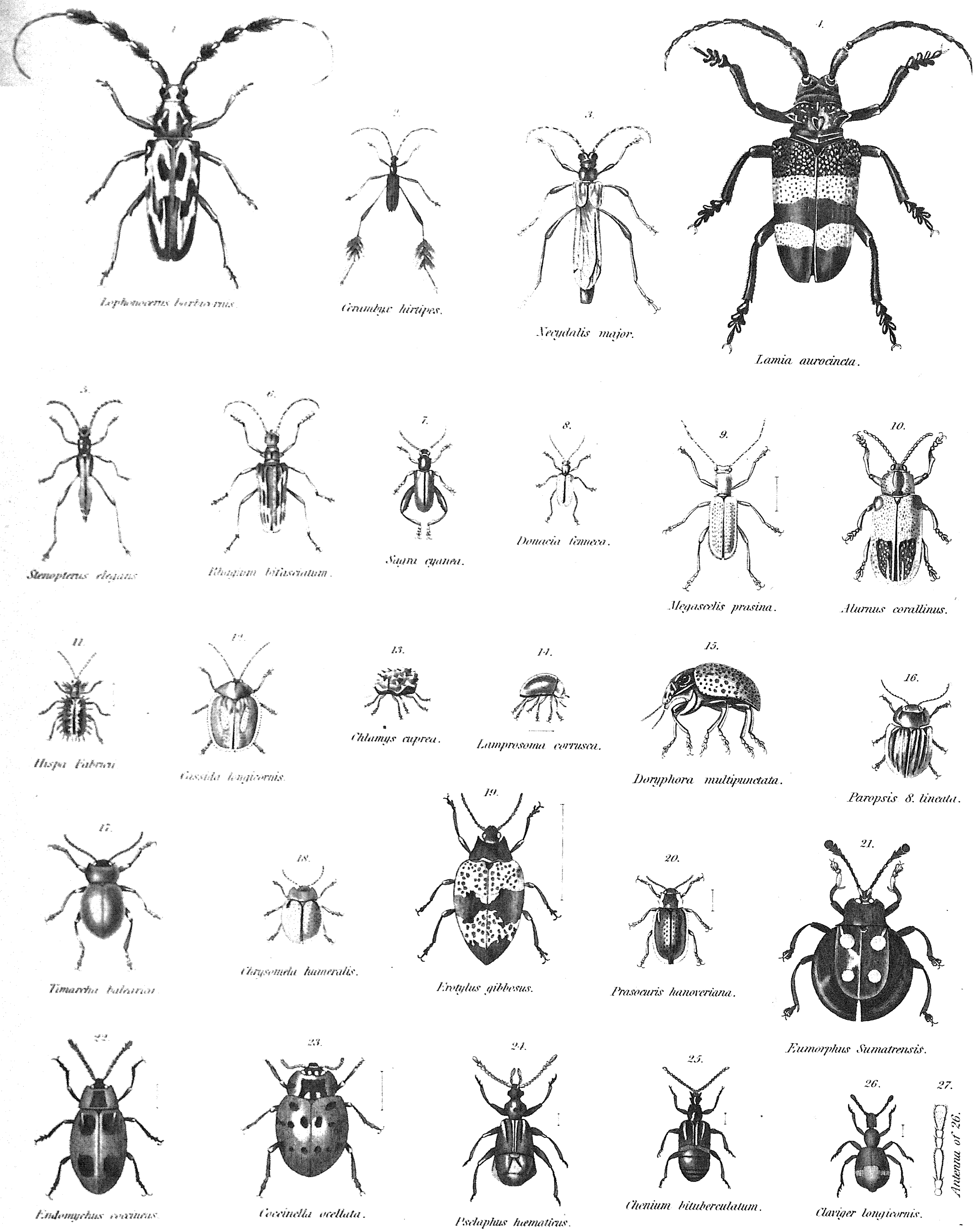
Cetonia Baxii.
Gymnetis nervosa.
Macronota aegregia.
Lucanus cinnamomeus.
Goliathus giganteus.
Lamprima aenea.
Head of Passalus.
Trachynotus vittatus.
Moluris luteipes.


Diaperis boleti
Upis ceramboides
Pyrochroa cardinalis
Ripiphorus bimaculatus
Mordella fasciata
Mylabris chicorii
Meloe proscarabeus
Corticus celtis
Cantharis vesicatoria
Brentus
Bruchus pisi
Curculio ligustici
Lixus paraplecticus
Orchestes alni
Tenebrio molitor
Bostrichus capucinus
Antenna of Orthocerus muticus
Dasycerus sulcatus
Blaps mortisaga
Heterotarsus tenebrioides
Tarsus of 26.
Antenna of 26
Tarsus of 30.
Tarsus of 30.
Lissonotus unifasciatus
Trachyderes nigrofasciatus
Prionus Desmarestii



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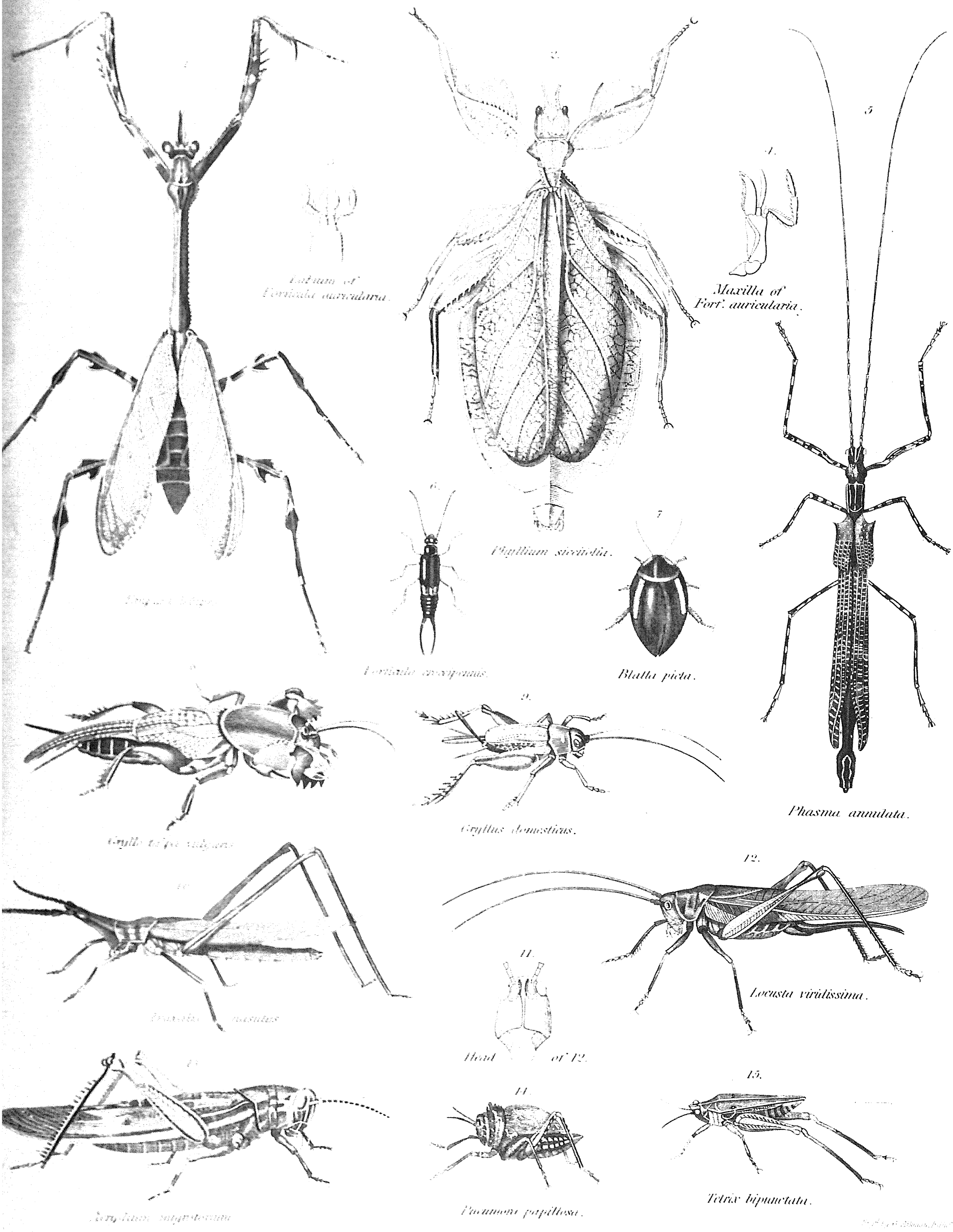
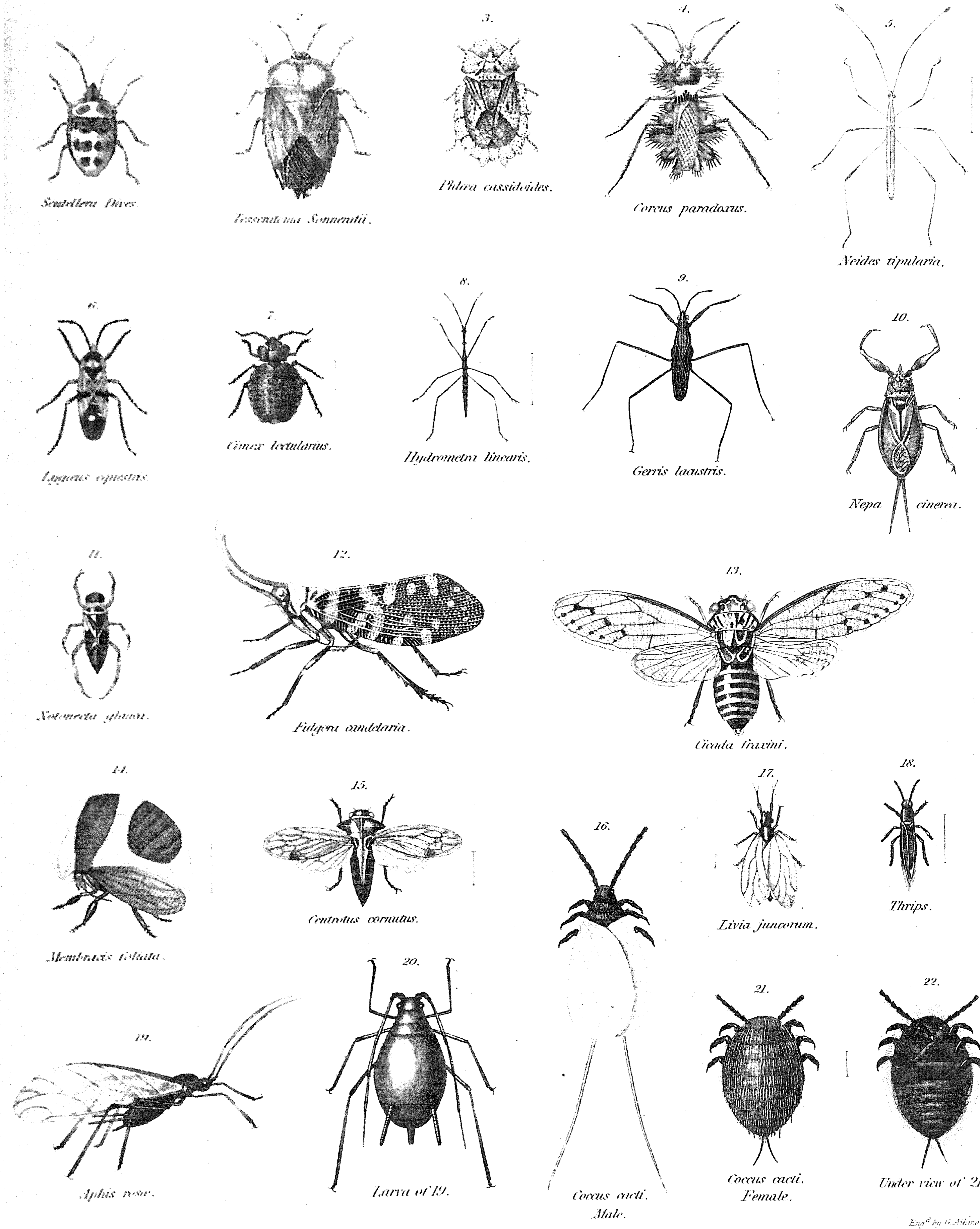
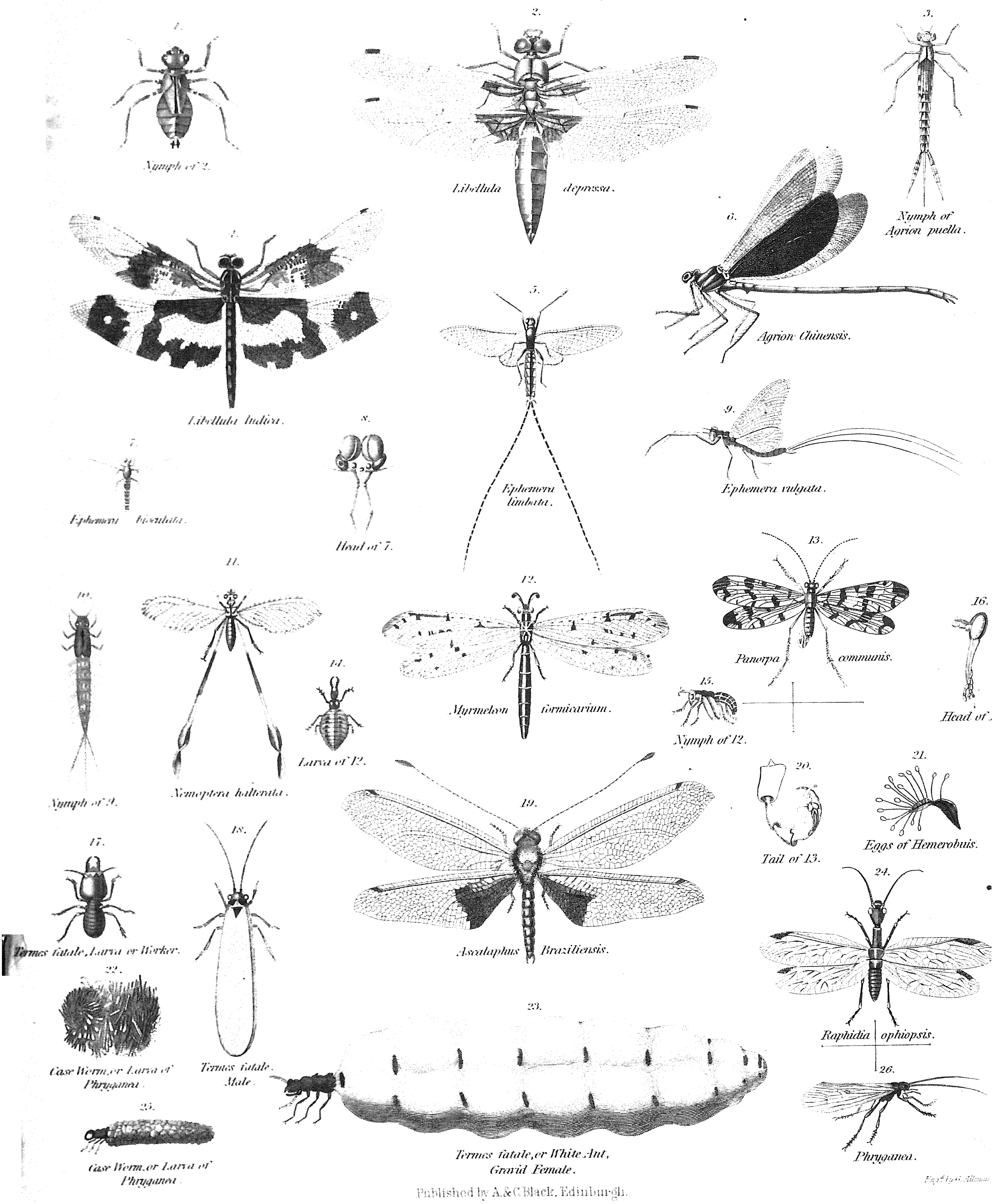

2.
4.
5
Labium of Forficula auricularia.
Maxilla of Fort. auricularia.
6.
7
Phyllium siccifolia.
Blatta picta.
Phasma annulata.
9.
Gryllus domesticus.
12.
Locusta viridissima.
11.
Head of 12.
14.
15.
Pneumora papillosa.
Tetrix bipunctata.



1. *Scutellera Dives.*
2. *Tessaratoma Sonneratii.*
3. *Phlœa cassidoides.*
4. *Coreus paradoxus.*
5. *Neides tipularia.*
6. *Lygaeus equestris.*
7. *Cimex lectularius.*
8. *Hydrometra linearis.*
9. *Gerris lacustris.*
10. *Nepa cinerea.*
11. *Notonecta glauca.*
12. *Fulgora candelaria.*
13. *Cicada fraxini.*
14. *Membracis foliata.*
15. *Centrotus cornutus.*
16. *Coccus cacti. Male.*
17. *Livia juncorum.*
18. *Thrips.*
19. *Aphis rosæ.*
20. *Larva of 19.*
21. *Coccus cacti. Female.*
22. *Under view of 21.*

Eng^d by G. Aikman

Published by A. & C. Black, Edinburgh.



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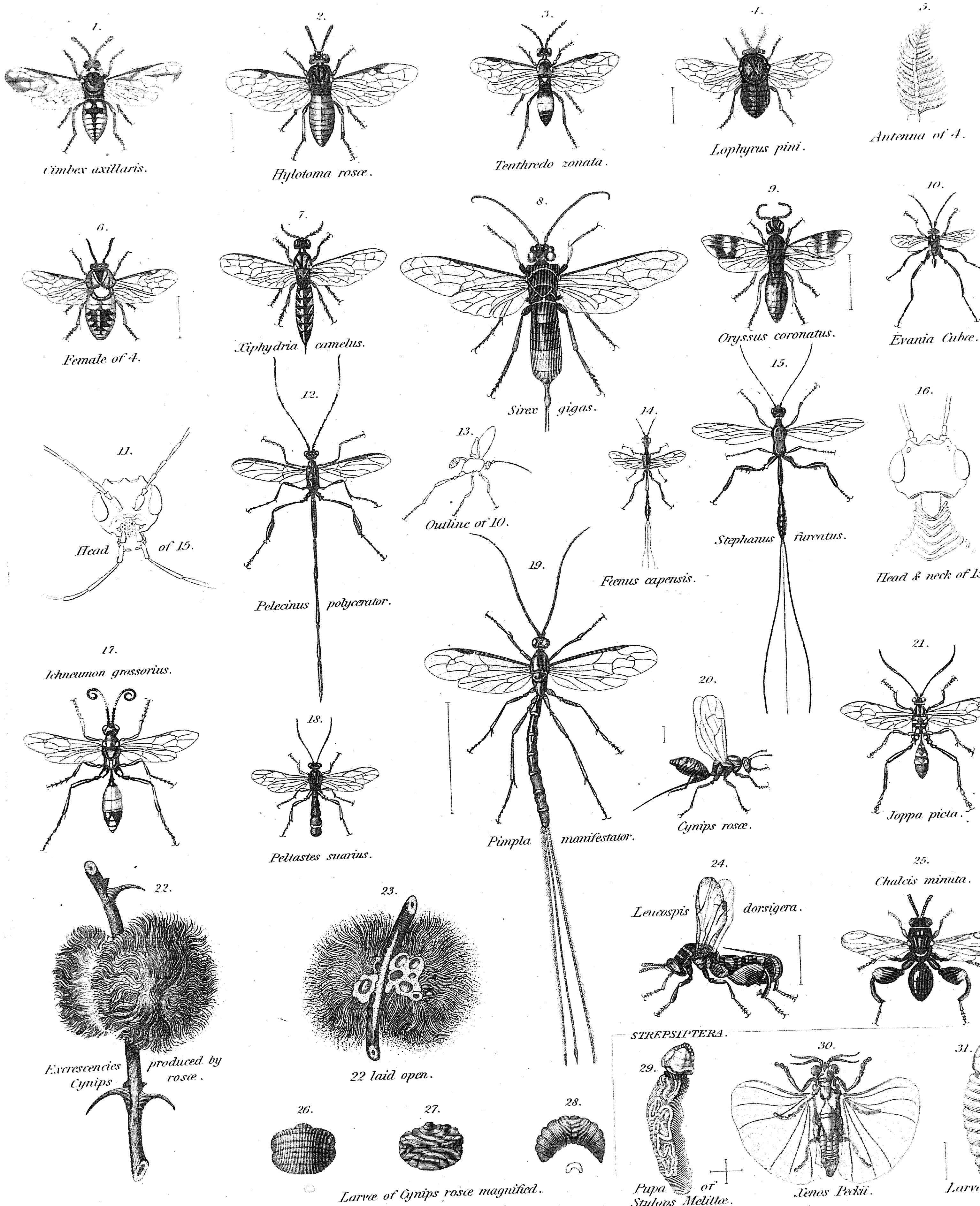
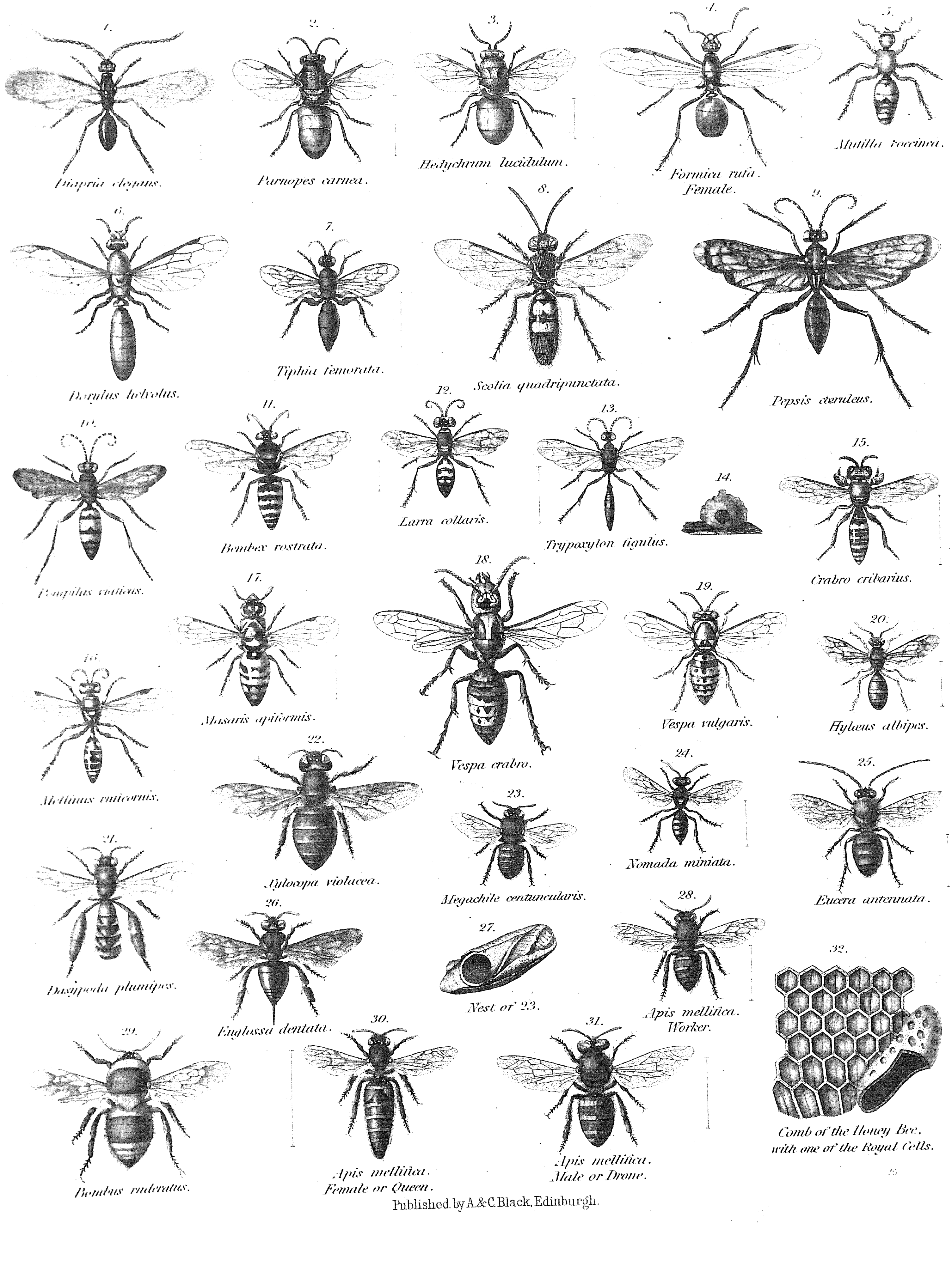
HYMENOPTERA.

ENTOMOLOGY.

PLATE CCXLIV.



Published by A.&C.Black, Edinburgh.



1. *Diapria elegans.*
2. *Parnopes carnea.*
3. *Hedychrum lucidulum.*
4. *Formica rufa. Female.*
5. *Mutilla coccinea.*
6. *Dorylus helvolus.*
7. *Tiphia femorata.*
8. *Scolia quadripunctata.*
9. *Pepsis cœruleus.*
10. *Pompilus viaticus.*
11. *Bembex rostrata.*
12. *Larra collaris.*
13. *Trypoxylon figulus.*
14.
15. *Crabro cribarius.*
16. *Mellinus ruficornis.*
17. *Masaris apiformis.*
18. *Vespa crabro.*
19. *Vespa vulgaris.*
20. *Hylæus albipes.*
21. *Dasypoda plumipes.*
22. *Xylocopa violacea.*
23. *Megachile centuncularis.*
24. *Nomada miniata.*
25. *Eucera antennata.*
26. *Euglossa dentata.*
27. *Nest of 23.*
28. *Apis mellifica. Worker.*
29. *Bombus ruderatus.*
30. *Apis mellifica. Female or Queen.*
31. *Apis mellifica. Male or Drone.*
32. *Comb of the Honey Bee, with one of the Royal Cells.*

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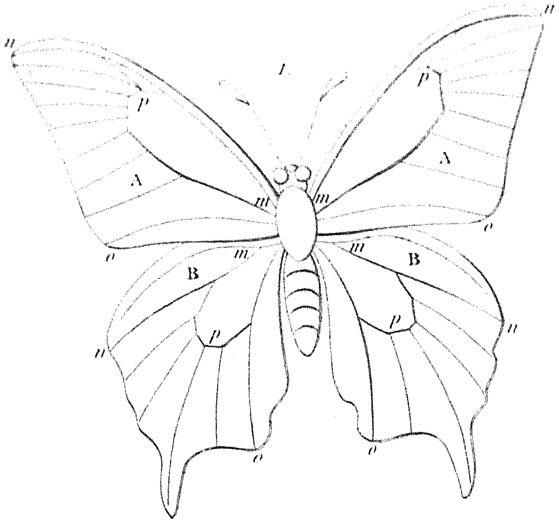
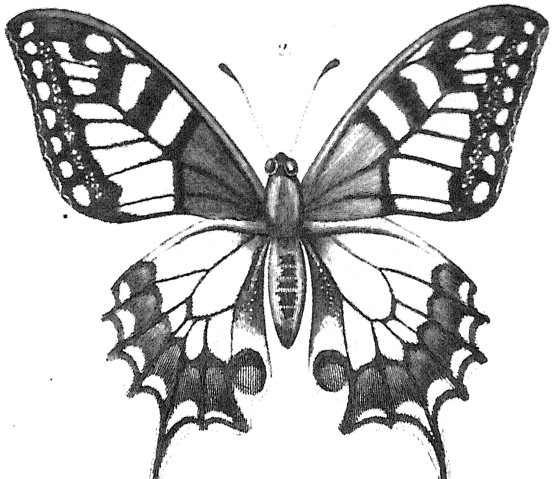
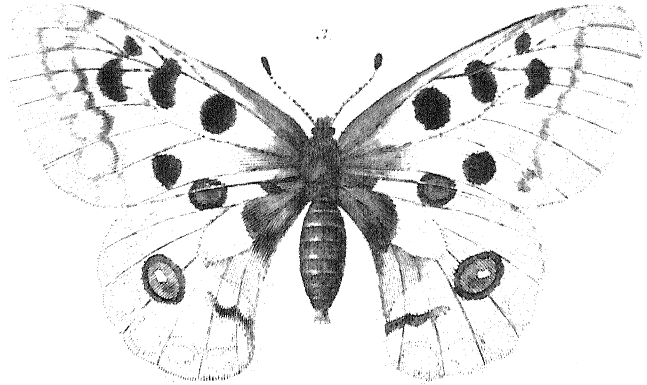
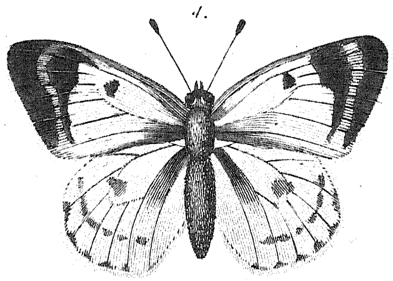
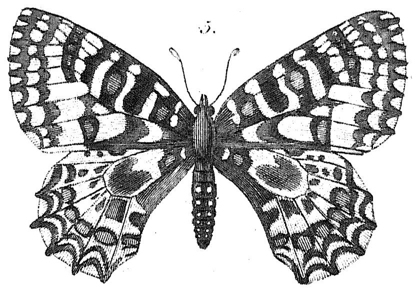
ENTOMOLOGY.

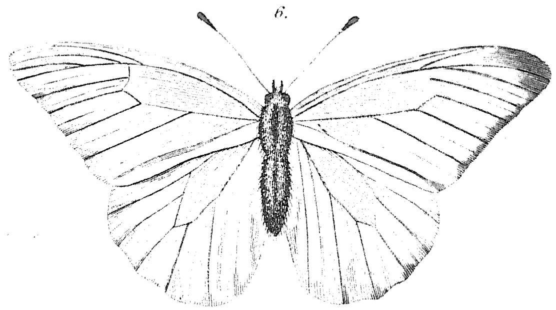


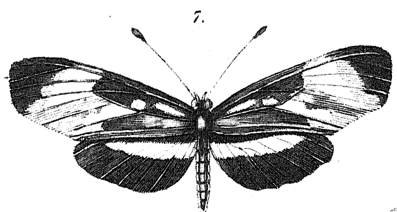

2\. Papilio Machaon.


3\. Parnassius Apollo.

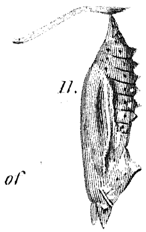

4\. Colias Hyale.


5\. Thais Medesicaste.

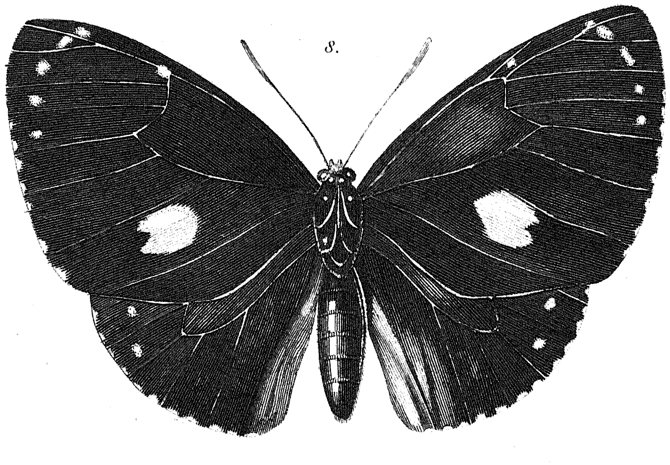

6\. Pieris thiria.

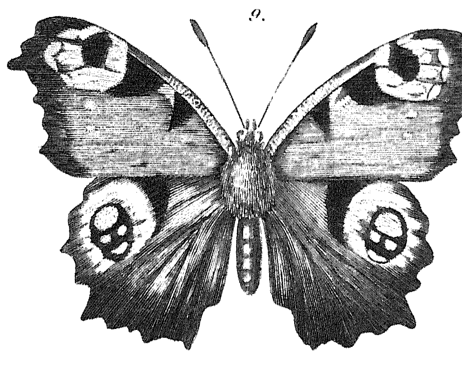

7\. Heliconius Langsdorfii.


10.


11.

Larva and Chrysalis of Vanessa Io.


8\. Danaida eunice.


9\. Vanessa Io.

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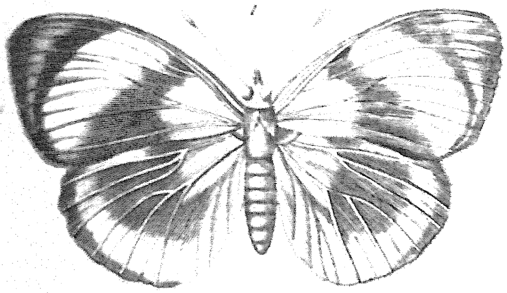
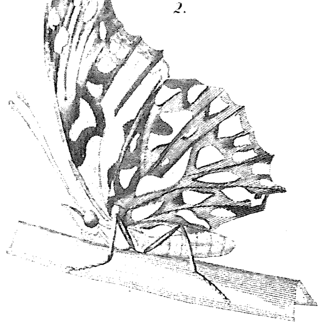
1.



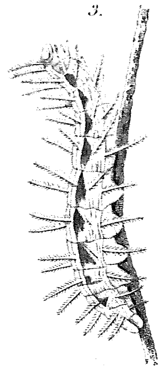
Vanessa callithea.

2.



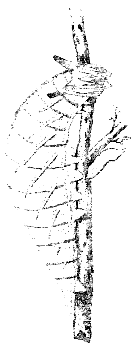
Argynnis moneta.

3.



Larva of
Argynnis paphia.

4.

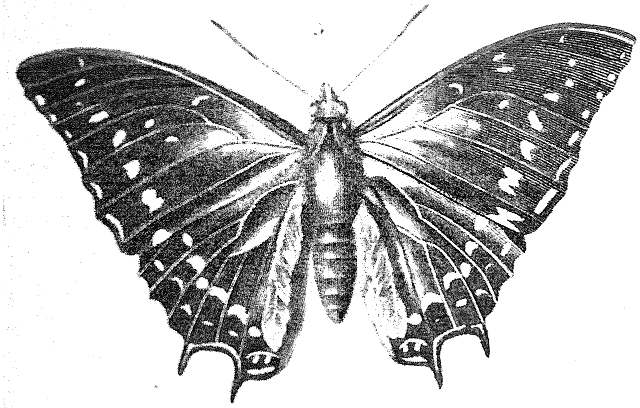


Larva of
Nymphalis ilia.

6.

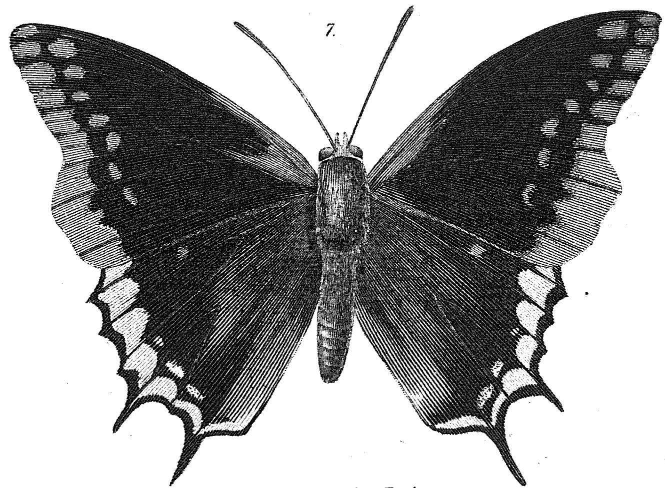
Chrysalis of
Nymphalis ilia.

5.



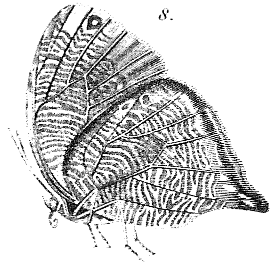
Nymphalis ethea.

7.



Nymphalis Jasius.

8.

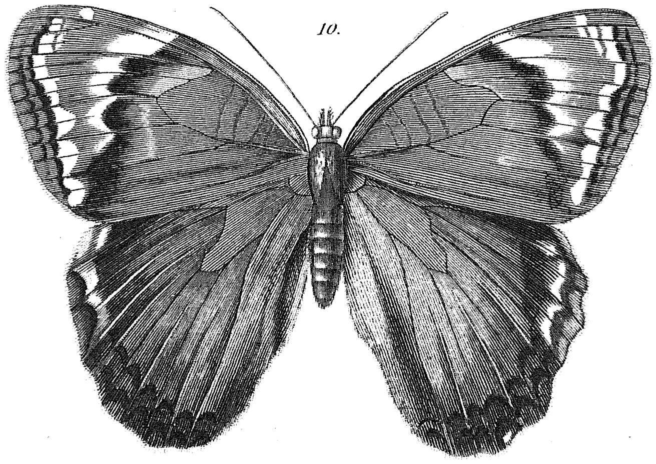


Morpho actorion.

9.

Nymphalis Jasius.

10.



Pavonia acadina.

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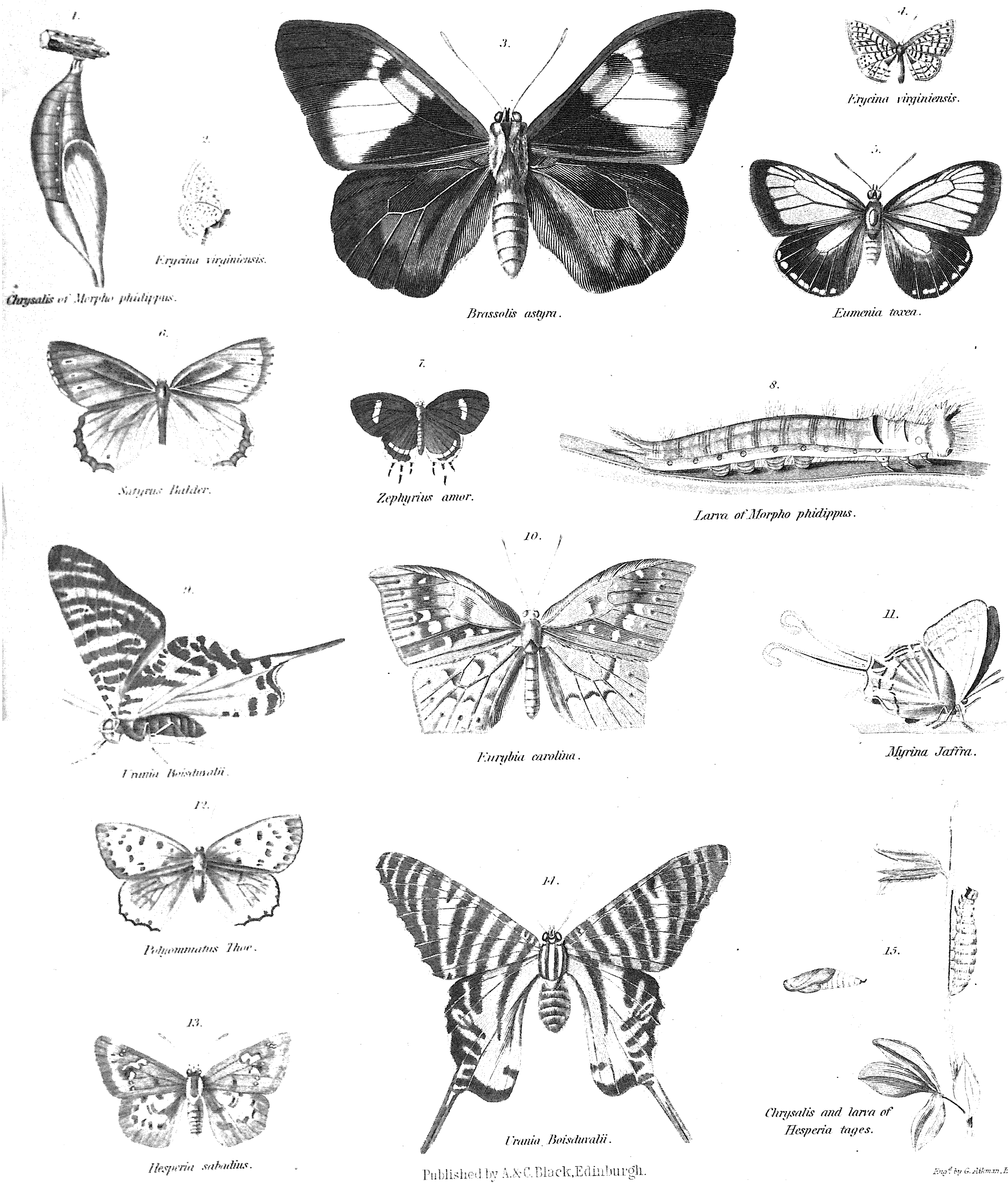
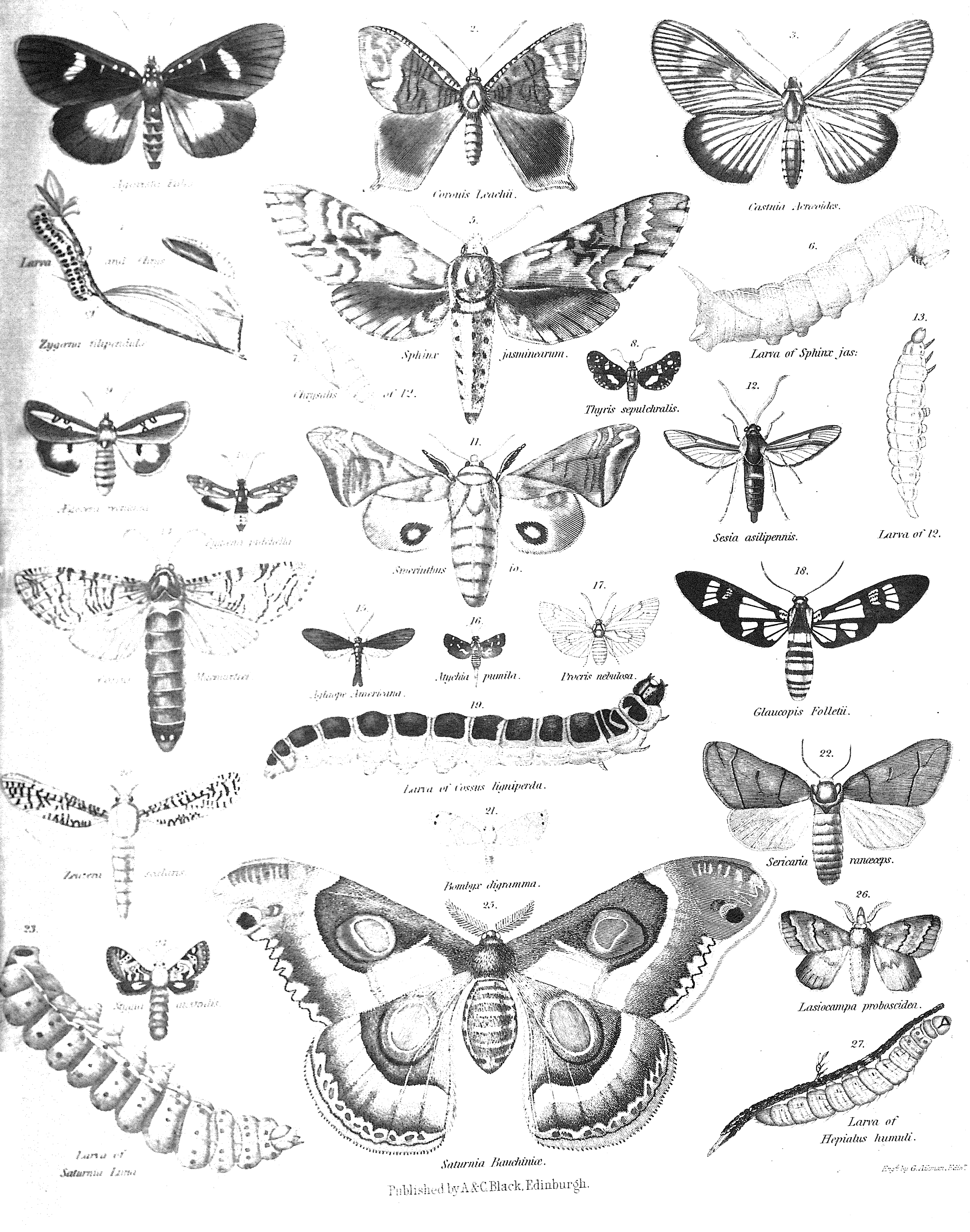


Published by A.&C. Black, Edinburgh.

Engd. by G. Aikman, Edinr.



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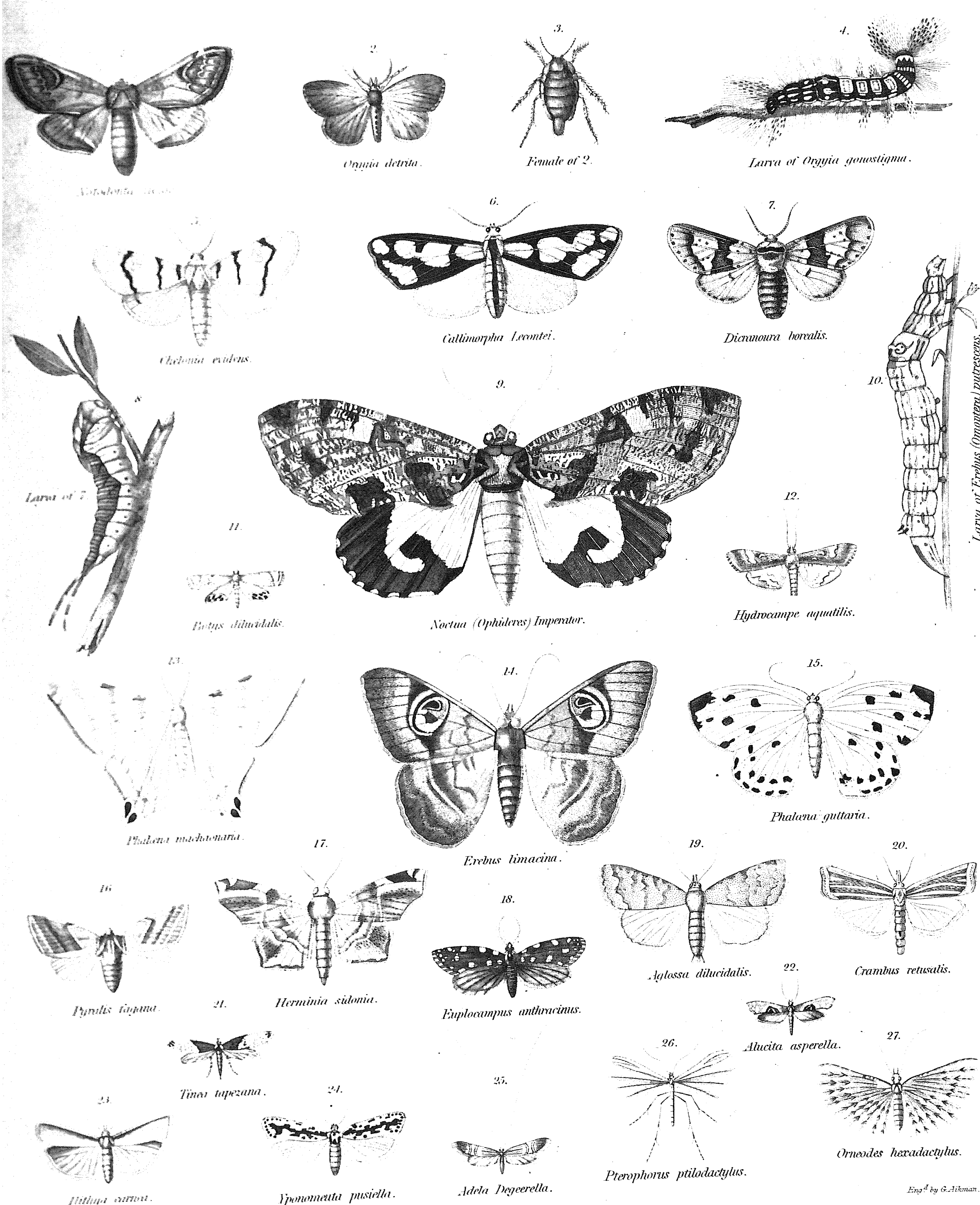
LEPIDOPTERA. ENTOMOLOGY. PLATE CCL.



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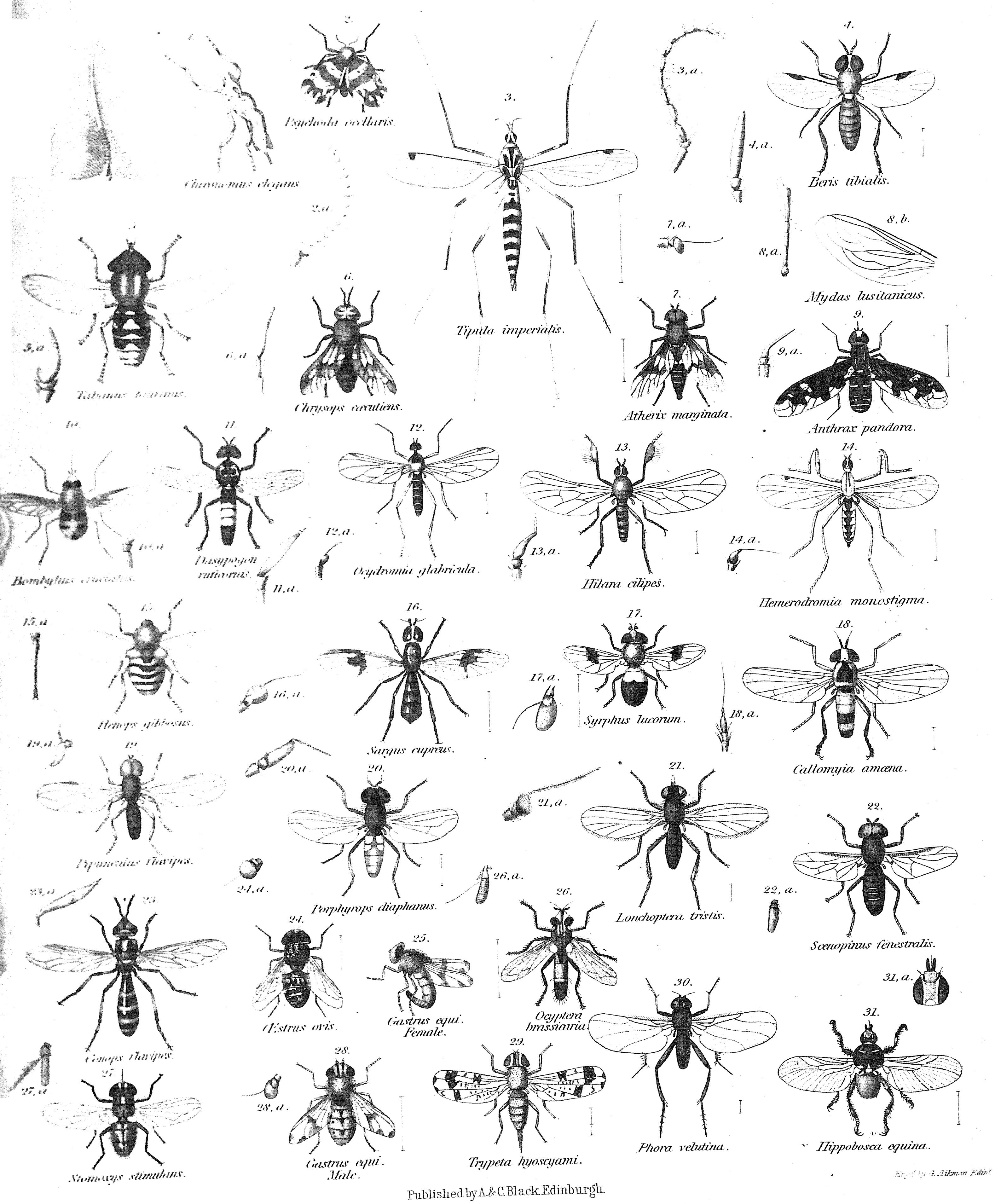

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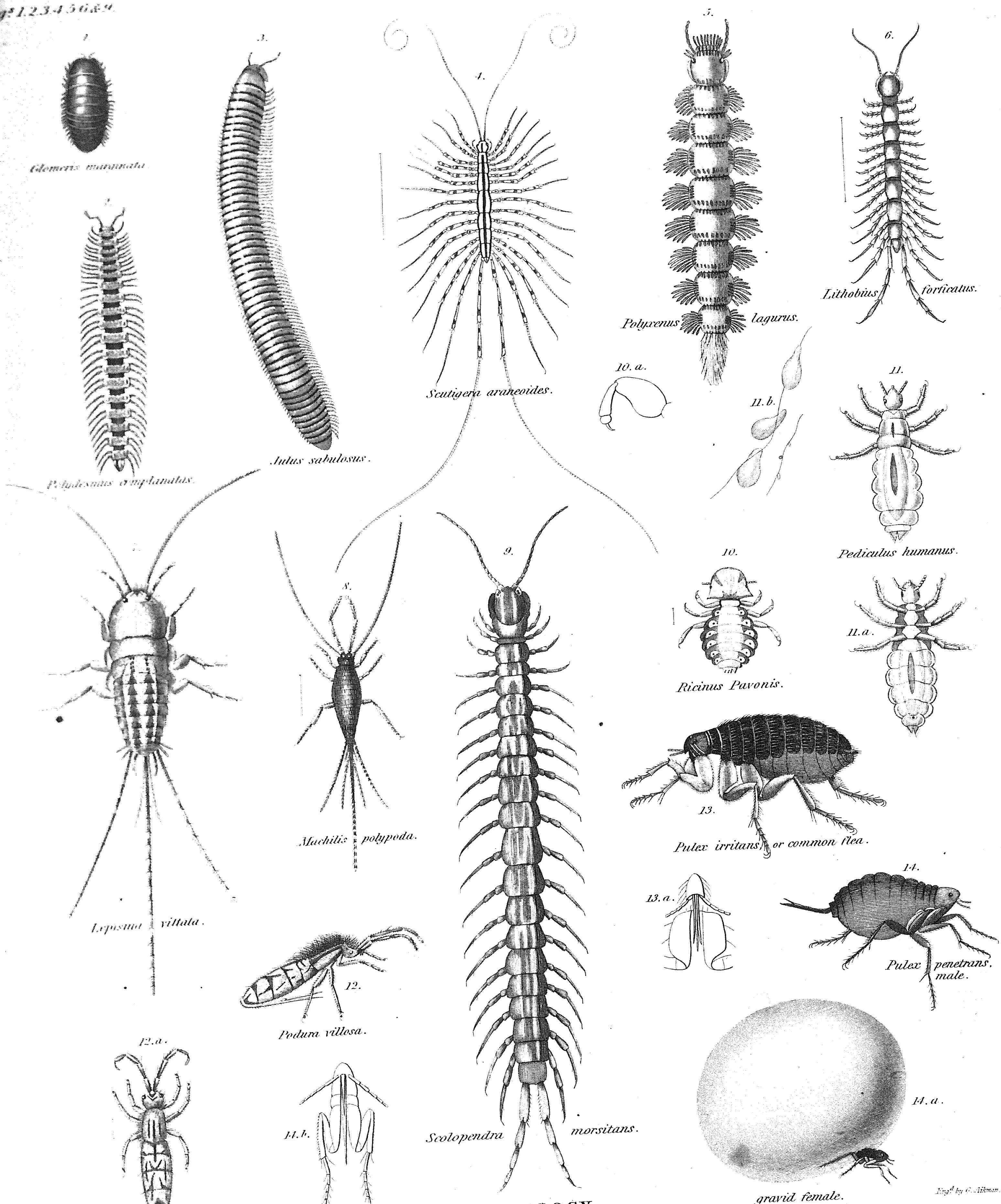
ENTOMOLOGY AND MYRIAPODA.

MYRIAPODA
Figs 1.2.3.4.5.6&9.



ENTOMOLOGY.

SUCTORIA, Figs 13, 13 a, 14, 14 a & 14 b. | THYSANOURA, Figs 7, 8, 12 & 12 a. | PARASITA, Figs 10, 11 & 11 a.

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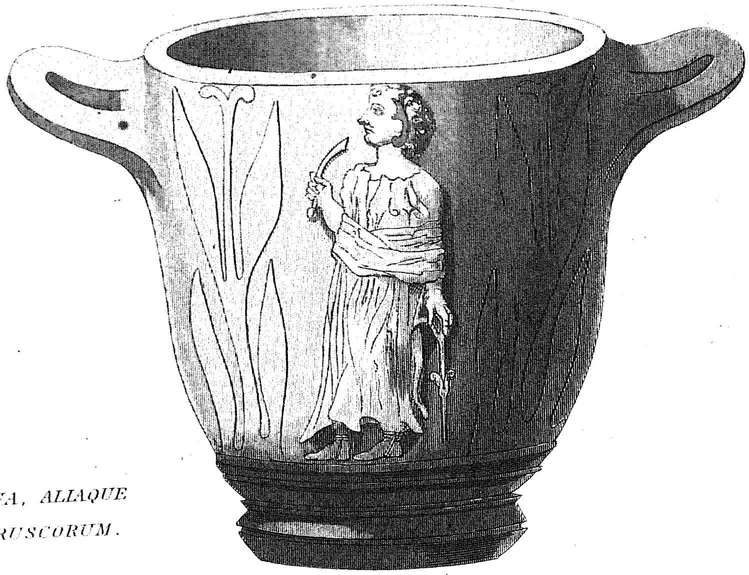
ULYSSES APUD CIRCEN POTUS.

BELLONA ETRUSCORUM.



DRACO, LEAENA, ALIAQUE MONSTRA ETRUSCORUM.

MUSICA ET POESIS ETRUSCORUM.

SACRA CEREALIA ET LENAEA.

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Geo. Aikman, Sculpt.

ETRUSCAN VASES.

JOVIS FESTUM ET SACRUM.

VENERIS ET HYMENAEI SACRUM

HYMENAEUS.

ACHILLIS FATA.

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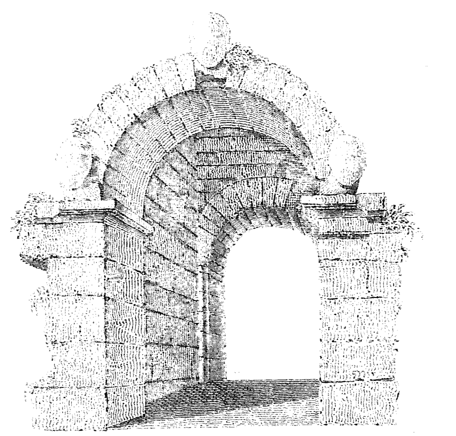
ETRUSCAN ANTIQUITIES.

PLATE CCLV.

See Micali, Italia.



Engd by G. Aikman Edinr

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PLATE CCLIV

Edinburgh, Published by A. & C. Black.

Engraved by S. Hall, Bury Str. Bloomsb.

Fig. 1.

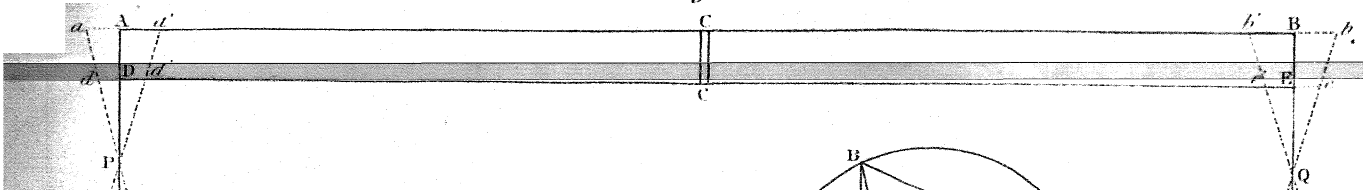


Fig. 2.

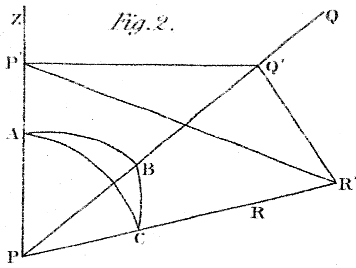


Fig. 3.

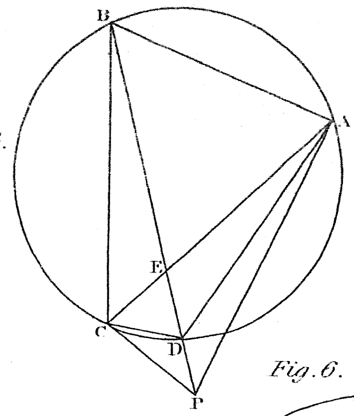


Fig. 4.

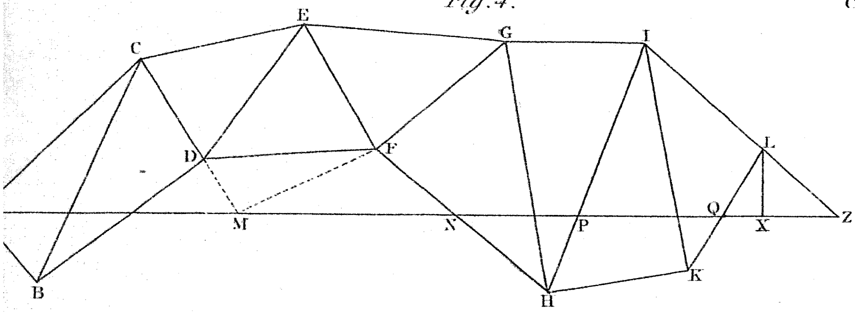


Fig. 5.

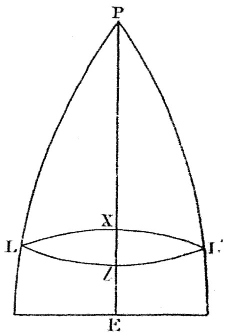


Fig. 6.

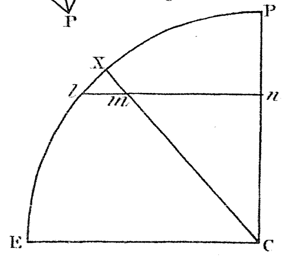


Fig. 7.

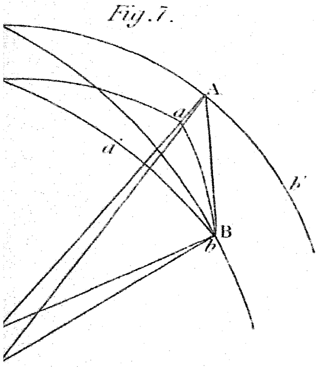


Fig. 8.

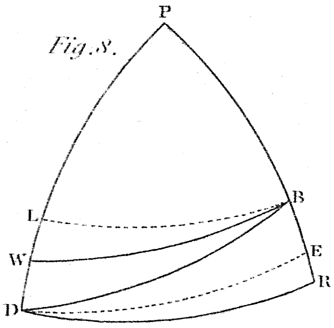


Fig. 9.

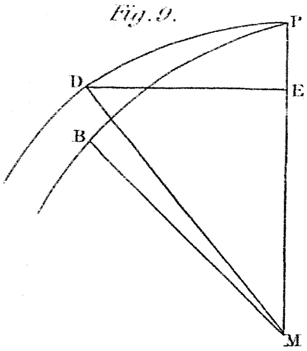


Fig. 10.

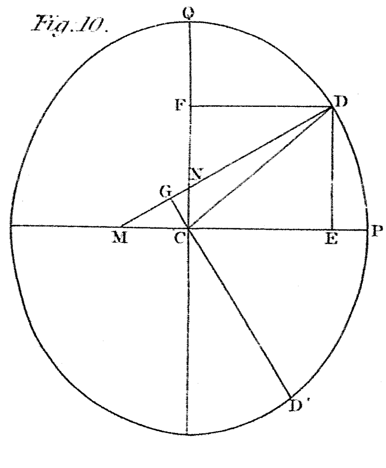


Fig. 11.

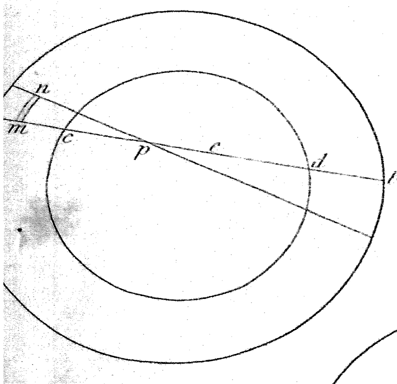


Fig. 12.

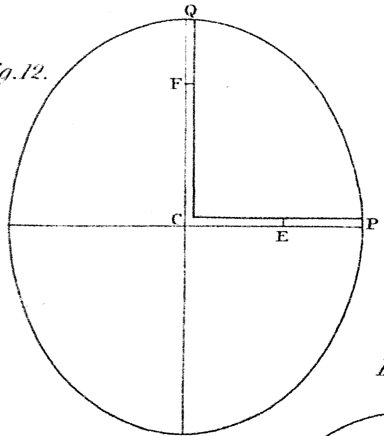


Fig. 13.

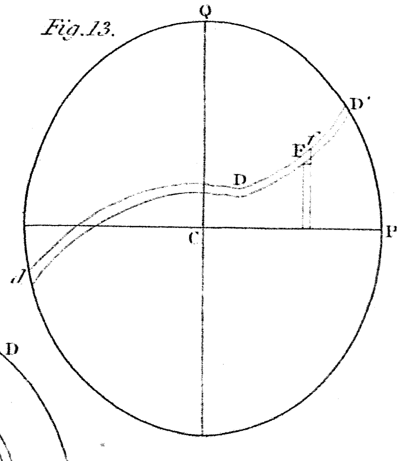


Fig. 14.

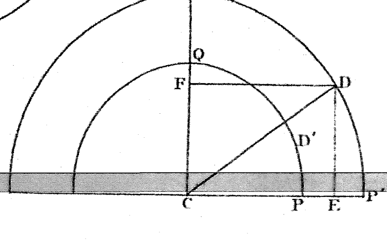
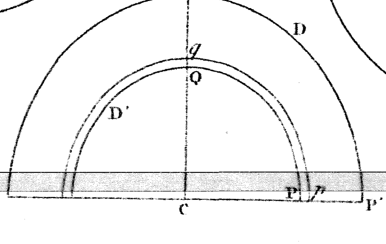


Fig. 15.



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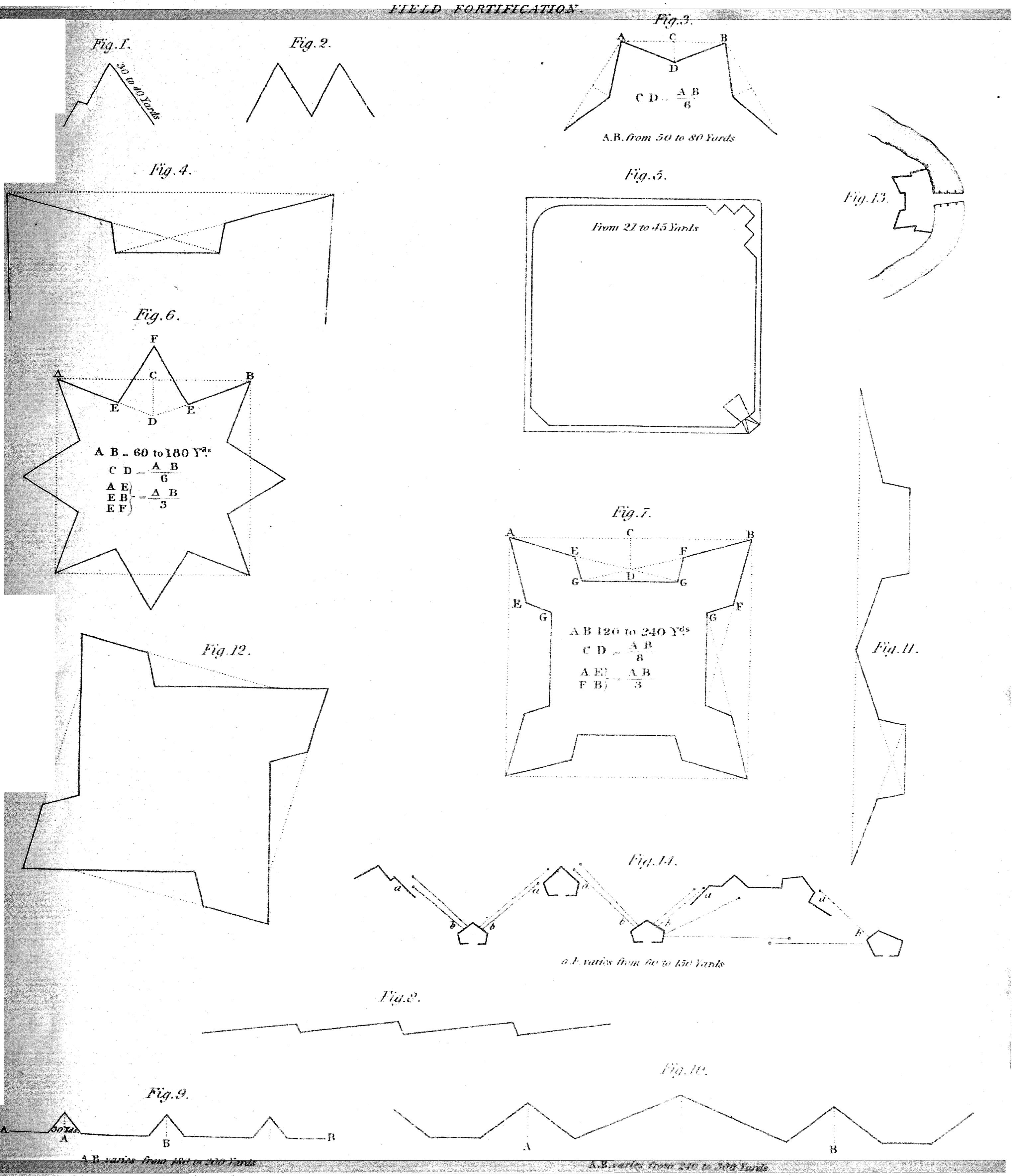
FILTER.

PLATE CCLVIII.



ud. Shaw. Roy! Art? Del!

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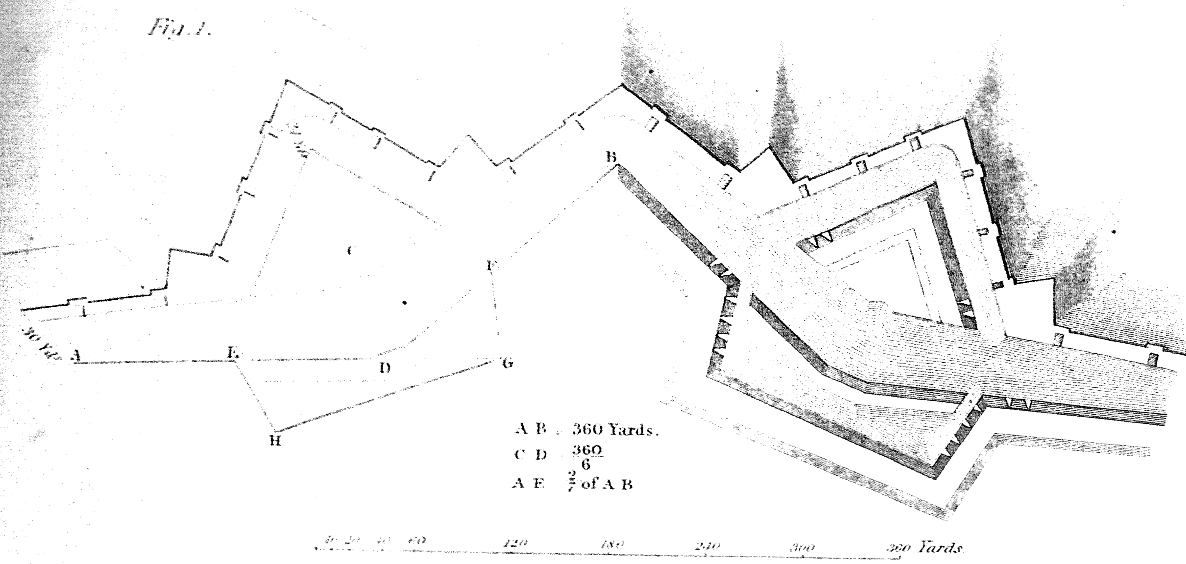
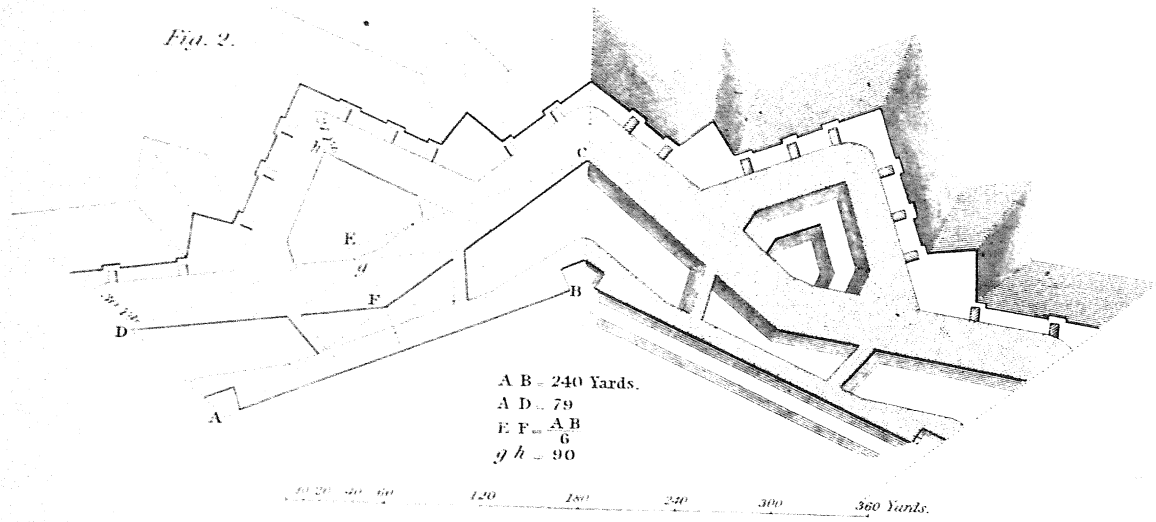
VAUBAN'S FIRST SYSTEM.

Fig. 1.



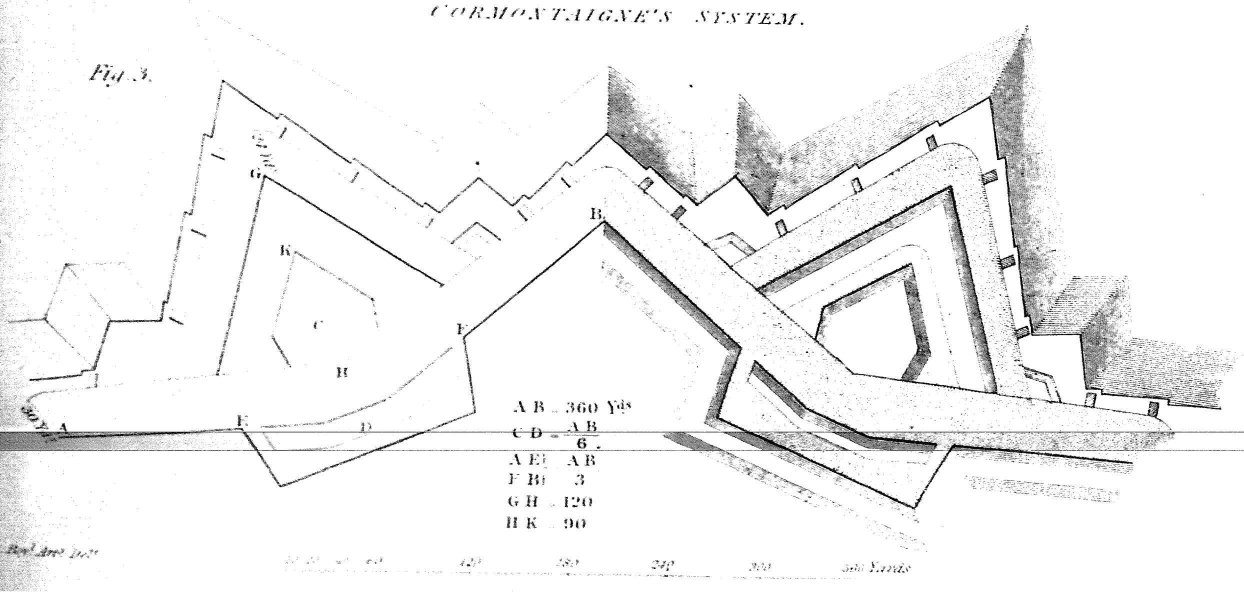
VAUBAN'S SECOND SYSTEM.

Fig. 2.



CORMONTAIGNE'S SYSTEM.

Fig. 3.



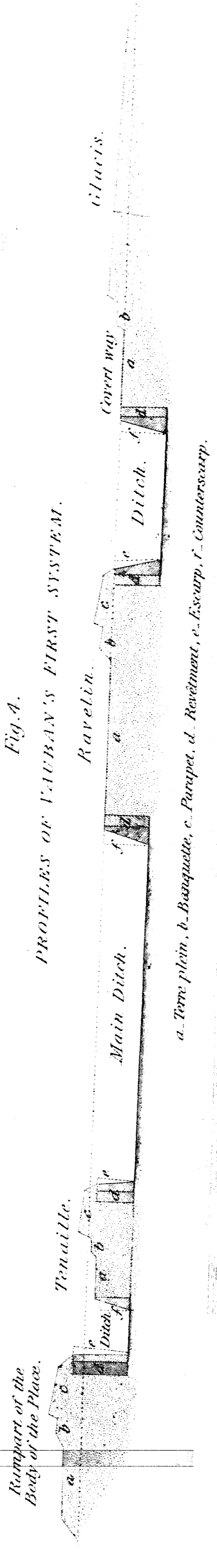


Fig. 4. PROFILES OF VAUBAN'S FIRST SYSTEM.

a. Terre plein, b. Banquette, c. Parapet, d. Revêtment, e. Escarp, f. Counterscarp.

Mud. Shaw Royl. Artʸ. Delᵗ. Engᵈ. by G. Aikman, Edinʳ.

Fig. 1.

COEHORN'S SYSTEM.

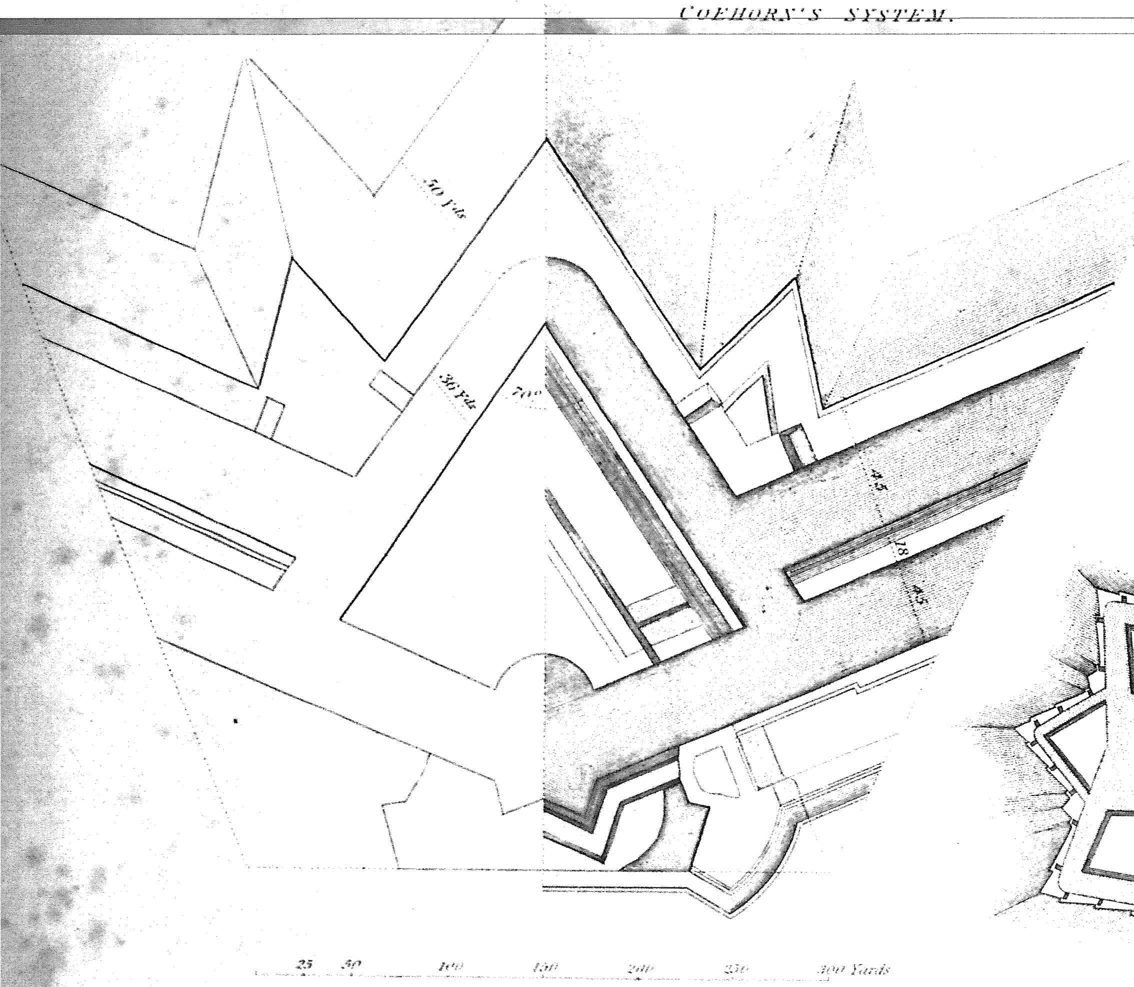
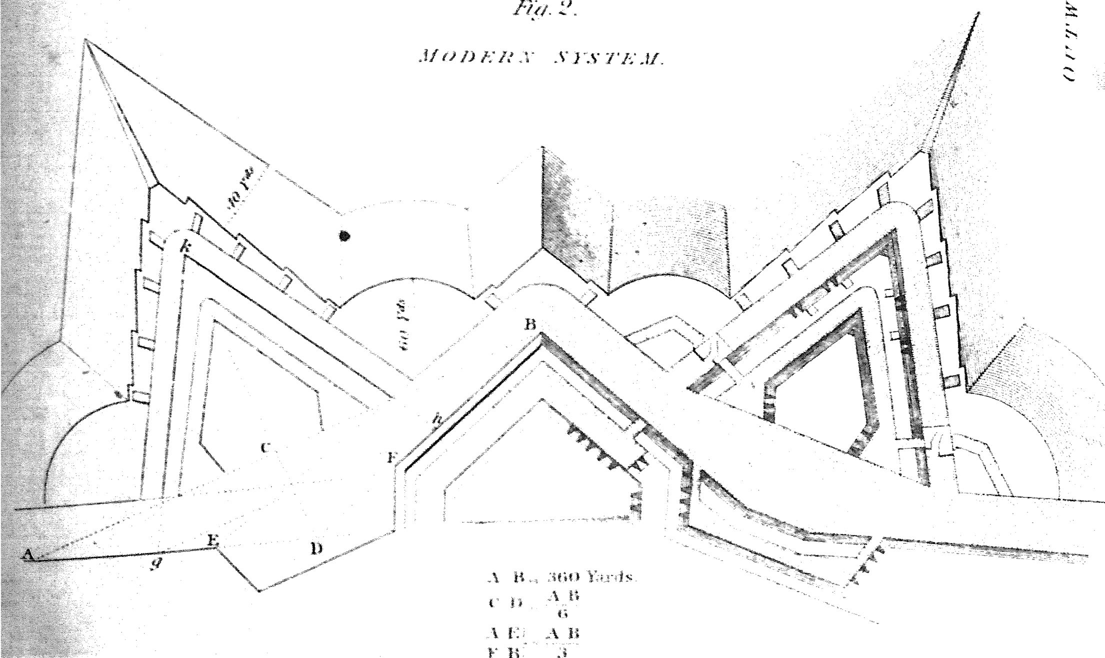


Fig. 2.

MODERN SYSTEM.



A B = 360 Yards.
C D = $\frac{AB}{6}$
A E = F B = $\frac{AB}{3}$
gh = gkhk

OUTWORKS

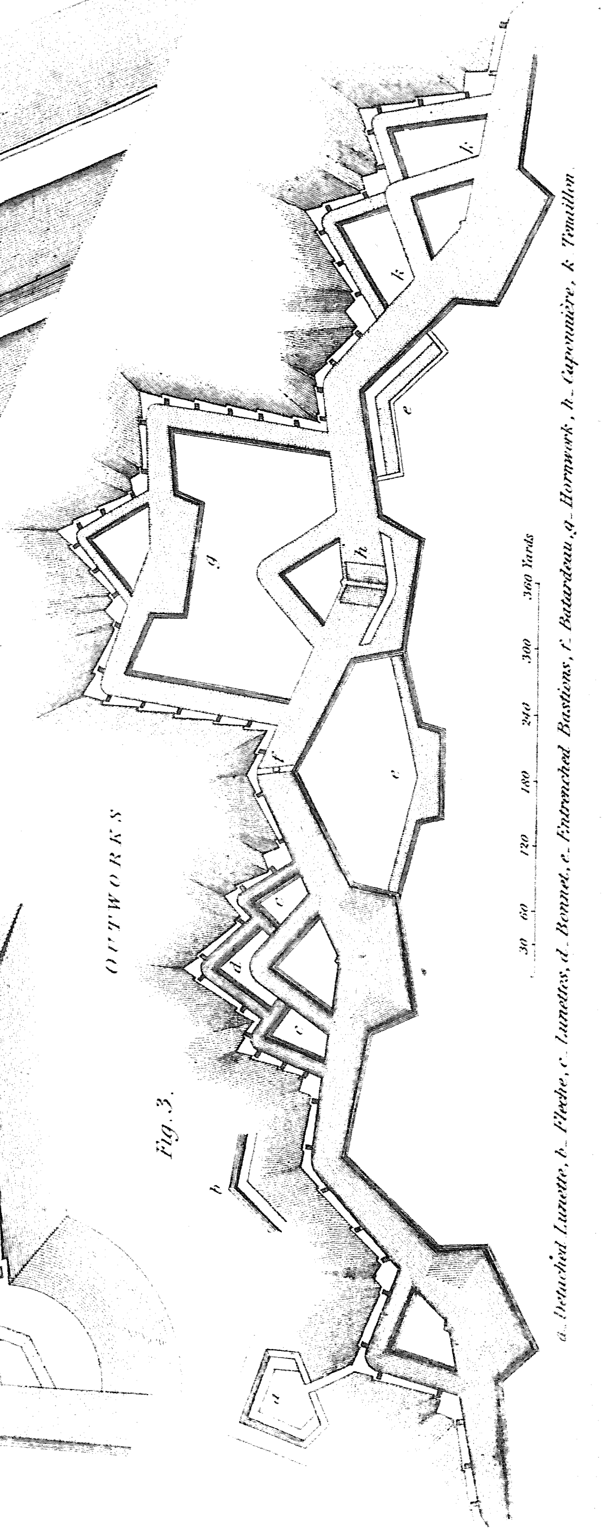


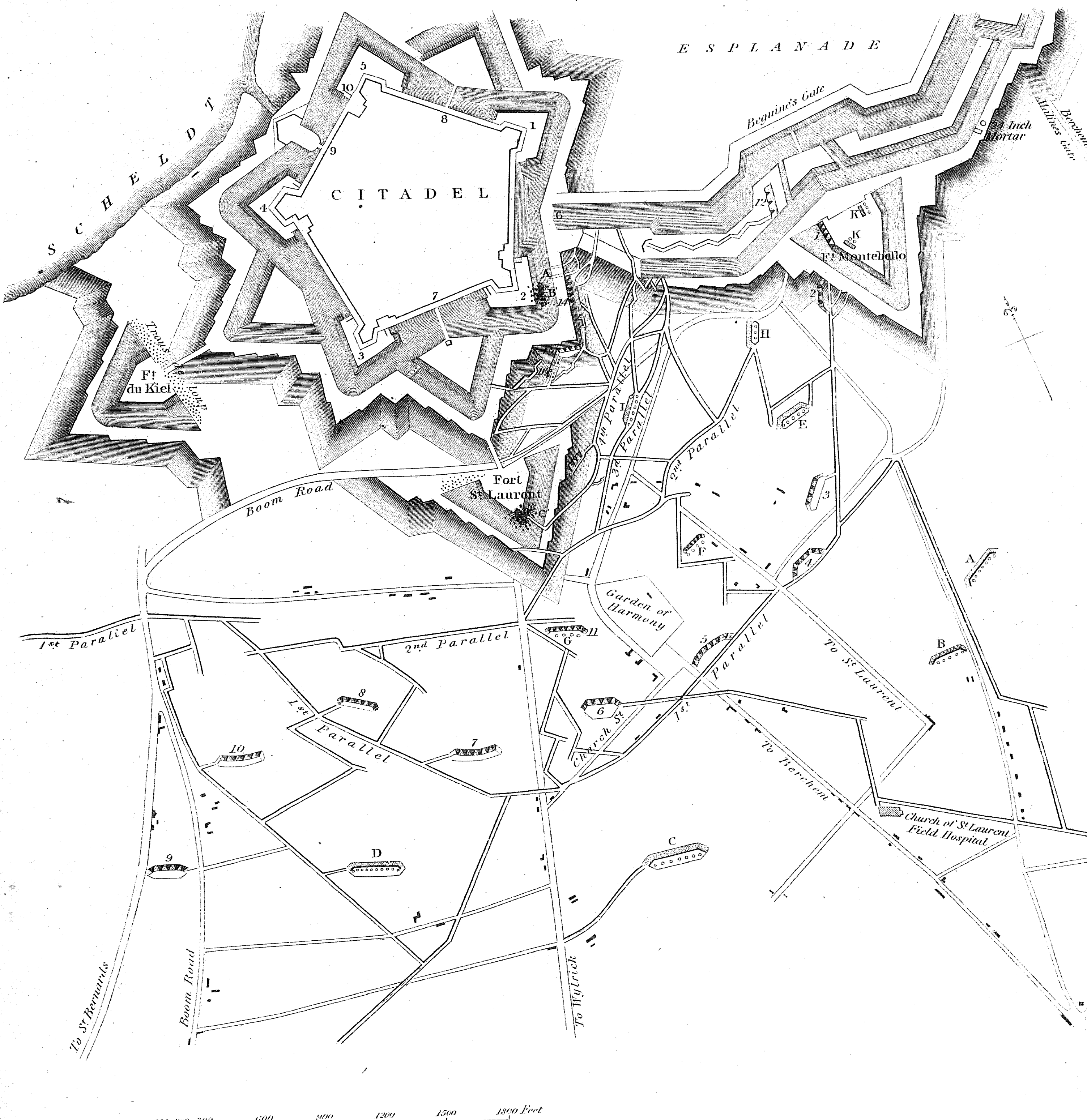
Fig. 3.

a. Detached Lunette, b. Fleche, c. Lunettes, d. Bonnet, e. Entrenched Bastions, f. Batardeau, g. Hornwork, h. Caponnière, k. Tenaillon

ud Shaw, Royl Archt Delt

PLAN of ATTACK of the CITADEL of ANTWERP from 29th Novr. to 23rd Decr. 1832.

1 _ Fernando
2 _ Toledo
3 _ Paciotto
4 _ Duke
5 _ Alba
6 _ Batardeau
7 _ Port de Secours
8 _ Port de la Ville
9 _ Port de l'Escaut
10 _ Genl. Chassé Casemate
A' Descent into Ditch
B' Breach
C' Descent into Ditch of the Ravelin.



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